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ABSTRACT

This book, developed for adult educators who teach or tutor reading in General Educational Development (GED) classrooms and for teacher trainers, contains 18 fact sheets on learning and thinking, each about 10 pages long. The following fact sheets are included: (1) Literature Is Not Science; (2) Making Connections; (3) Mental Models; (4) Thinking about Thinking; (5) Getting Information into Memory; (6) Memory and Learning; (7) Working Memory and Learning; (8) Long-Term Memory and Learning; (9) How Thinking Develops, Part 1--General and School-Based Development; (10) How Thinking Develops, Part 2--Changes in Strategies; (11) How Thinking Develops, Part 3--Experience Makes Some Difference for Adults; (12) The Importance of Teaching Content; (13) What Does Good Thinking Look Like; (14) Critical Thinking; (15) Active Learning; (16) Problem-Based Learning; (17) Supporting Good Thinking; and (18) Adult Learning. The fact sheets incorporate learning methods based on cognitive research, including questions for teacher reflection; quotes from teachers, learners, and researchers that show how the information presented is relevant to teaching; a summary of the ideas and evidence; what this means for teachers; and a set of short lesson ideas based on the findings. The book also contains appendixes on two frequently-asked questions ("Are there learning styles?" and "What about the brain?"); nine short articles summarizing many of the fact sheets; a selected, annotated bibliography with 14 references; a glossary of 26 technical terms used in the book; and an index. (KC)

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Learning to Think, Learning to Learn:

What The Science Of Thinking And Learning Has To Offer Adult Education

Jennifer Cromley
Literacy Leader Fellow, 1998-99

NIFL Literacy Leader Fellowship
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Volume IV
Number 1

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Contacting Jennifer Cromley:

You can contact Jennifer Cromley at jcromley@aol.com.

Table of Contents

Introduction iv
The "Cognitive Revolution" in the classroom
Teaching means teaching students to think
What is research? What does it have to offer teachers?
Is this book for me?
How to use this book

Fact Sheet 1: Literature is not Science 1

Fact Sheet 2: Making Connections 11

Fact Sheet 3: Mental Models 25

Fact Sheet 4: Thinking About Thinking 37

Fact Sheet 5: Getting Information into Memory 47

Fact Sheet 6: Memory and Learning 59

Fact Sheet 7: Working Memory and Learning 63

Fact Sheet 8: Long-Term Memory and Learning 73

Fact Sheet 9: How Thinking Develops, Part 1: General and School-Based Development 85

Fact Sheet 10: How Thinking Develops, Part 2: Changes in Strategies 97

Fact Sheet 11: How Thinking Develops, Part 3: Experience Makes Some Difference for Adults 107

Fact Sheet 12: The Importance of Teaching Content—A Summary 117

Fact Sheet 13: What Does Good Thinking Look Like—A Summary 125

Fact Sheet 14: Critical Thinking 137

Fact Sheet 15: Active Learning—A Summary 147

Fact Sheet 16: Problem-Based Learning 157

Fact Sheet 17: Supporting Good Thinking 171

Fact Sheet 18: Adult Learning—A Summary 183

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The Literacy Leader Fellowship program provides an opportunity for those dedicated to literacy in a professional, volunteer, or learning capacity to conduct projects of their own design that will benefit the literacy field. The Fellowship program helps bring innovative ideas to the field quickly and directly.

Previous Literacy Leader Fellows have studied welfare-to-work, the role of technology in adult education, state policies on workplace education, the nature of adult learning, and the use of health topics in adult literacy classes. Reports generated by these and other studies may be ordered by contacting the Institute or may be accessed on the NIFL's website, http://www.nifl.gov/activities/fllwname.htm.

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Introduction

What's new in learning—the "cognitive revolution" in the classroom

Thirty years ago, most theories about teaching and learning (for children and adults) were based on drill. The idea was that if facts were repeated enough, then students would memorize them, and this was learning. According to a 1954 teacher training textbook, "Learning is shown by a change in behavior as a result of experience."[1] Notice that nothing is mentioned about what students believe, what process they use to solve problems, or their own awareness of their thinking. Although adult educators like Paolo Freire and Malcolm Knowles encouraged teachers to use real-life examples that students were interested in, most adult reading workbooks looked about the same as children's drill-based workbooks. This approach can be described as a "behaviorist" approach to learning.

Since the 1970s, the field of cognitive psychology has taken a different approach—looking at what people believe about what they are studying, how they go about solving problems, and how aware they are of whether they understand what they are reading. This research has produced a lot of useful knowledge about thinking and learning and has had a big impact on our understanding of what can be most effective in the classroom. **Most of this research has not filtered down to teachers** (except those trained as K-12 teachers in about the last five years). In its simplest version, a cognitive approach to learning says that teaching is most effective when it is based on certain **research-based**[2] facts about how the mind works:

- Skills need to be taught in the context in which they will be used. For example, if students are learning to add fractions for a word problem test, they need to practice fraction word problems, not just adding fractions.
- Reading skills are subject-specific—understanding what you read in literature does not guarantee that you will read well in social studies.
- Problem-solving skills in one subject (like reading) are different from those in other subjects (like math). Problem-solving skills need to be taught separately for each subject.
- Since problem-solving skills do not automatically transfer from one subject to another, teachers need to show students how to transfer these skills and give them lots of practice.
- Students need more and better mental models of the world in order to learn and master new information and skills.
- Thinking skills such as inferring unstated facts need to be taught explicitly in the classroom, they do not develop on their own (except in a very few students). These strategies need to be practiced over and over again.
- Most adult learners have a very limited number of strategies for understanding new material or solving problems. Teaching them more strategies can help them learn much better.
- Learning lasts when the student understands the material, not just memorizes it.
- Information needs to be presented in small chunks so that working memory can process it.
- Students need immediate practice to move information from working memory to long-term memory.
- It is impossible to remember without associating new information with what you already know.

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Appendices

Appendix A: Annotated Bibliography 195
Appendix B: Are There Learning Styles? 197
Appendix C: What About the Brain? 203
Appendix D: Newsletter Articles 209
Glossary 221
Index 223

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Some teachers mistrust research because it is not done by practicing teachers. After all, most of us notice patterns in our classrooms and try to solve problems by trying new approaches, which is itself a kind of research. We make our own theories about why something is working or not working, then test these theories by continuing or changing our teaching practices. For example, if you teach a lesson on capitalization and students do not do well on a capitalization assignment, you may form an idea about why it did not work. You then choose a different approach for the lesson or choose different kinds of practice based on your diagnosis of why it went wrong.

What could researchers find out in the lab that we don't already know from the classroom? Sometimes our experiments work, and sometimes they do not. Sometimes our instincts about what is going on in the classroom show the full picture; sometimes they do not. I believe that what researchers have to offer is an additional set of ideas and approaches for diagnosing and solving problems in the classroom. For example, maybe your capitalization lesson did not work because students memorized a rule but did not know how to apply it. Research on how to teach strategies could help you teach this lesson in a way that works because it takes into account how students think and learn. This gives you one more tool for improving your teaching.

You will find three types of research in this report:

- Studies done in laboratories—most of the participants are young adult college students, but some are younger children
- Studies done by researchers in classes—most of the participants are children
- Studies done by teacher/researchers in their own classrooms—most of the participants are children, but some are adults.

Some teachers may also be familiar with theories of adult education that are based on the theorists' own teaching experiences, but not on controlled experiments. Such teachers may be heartened to find that familiar principles of adult education such as using real-life materials, surveying learners' interests, and using participatory teaching methods are well-supported by cognitive science research. They may also be disappointed to find that some "unpopular" teaching methods, such as individual classroom practice, repetition, and sometimes memorization are also supported by the research. The research is important because it adds another layer of confirmation to our own classroom experience.

Some researchers are actively trying to get research about thinking and learning to teachers. One valuable source is the quarterly newsletter *Focus on Basics*, which is available free on the Internet at http://gseweb.harvard.edu/~ncsall/fob1.htm or by subscription for $8 for 4 issues from World Education, *Focus on Basics,* ATTN: Kimberly French, 44 Farnsworth Street, Boston, MA 02210-1211. You may also want to explore the Theory Into Practice (TIP) Database at http://www.gwu.edu/~tip/.

What research has been done so far?

Very little research has been done on how Adult Basic Education (ABE) or General Educational Development (GED) students think and learn, and whether they think or learn differently from children or from other adults.[6] Most educational psychology textbooks do not mention adults, and when they do, it is often in the context of either college students or senior citizens.[7]

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- Thinking changes from being good at familiar subjects to being able to work in unfamiliar subjects.
- Background knowledge is vital—it affects memory, reading, thinking, and problem solving.
- People have informal beliefs about how the world works (e.g., about gravity), which interfere with learning.
- Good teachers need to know what topics tend to be hard for students in the specific subject they teach, and effective ways to help students get past those roadblocks. They need subject-specific teaching knowledge in addition to general teaching knowledge and subject knowledge.

This approach can be described as a "cognitive" or "constructivist" approach to learning, which is the focus of this book.

Teaching means teaching students to think

This book is based on the idea that teaching means teaching students to think. It assumes that teaching is not just about communicating facts or mechanical skills like math rules (of course, you must have facts in order to learn), but is a process of coming to understand the world. As Victoria Purcell-Gates says of teaching reading, "As teachers it is critical that we identify our assumptions and beliefs . . . about what it is we are trying to help our students do."[3] My assumption here is that students must think when they read in order to make sense out of what they read.

Lauren Resnick argues that thinking skills have always been a focus of "elite" schools but not of "mass schooling."[4] The idea that all students should learn how to think critically is a relatively new one (certainly since the turn of the 20th century) and one for which most schools are not well prepared. For example, thinking skills may best be formed through discussions, yet most schools have large classes with a teacher/lecturer up front facing silent students sitting in rows.

There is an abundance of "thinking skills" programs available to K-12 teachers, most of which assume that there are general problem-solving strategies that apply across all subjects. Cognitive research shows that strategies actually are quite specific, so it is no surprise that these programs do not work well. This report takes a different approach, namely that:

- all real learning involves active thinking and
- teaching should be based on what we know about how the mind takes in and organizes information.

What is research? What does it have to offer teachers?

Many adult education teachers never see any research on teaching, thinking, or learning. Who has time to find, much less read, those academic reports? If you do read it and understand it, what do the results mean in the classroom? The professors who do the research seem to many adult educators to be shut up in their ivory towers,[5] not making any effort to share what they know in an understandable way. Research studies often seem full of jargon and hard to relate to everyday teaching. Researchers in turn sometimes feel frustrated because teachers to do not seem to be using research results in their classrooms. The point of this report is to bridge this gap between research and practice for adult educators.

Traditional developmental psychology predicted that adult learners would not develop beyond the thinking skills they had when they left school,[8] even though those of us who have taught adults know that their thinking can develop significantly. Many developmental psychologists are now taking a broader life-span perspective and looking at how thinking develops in adults. Most core adult education textbooks do not mention educational psychology; rather, they are based on the authors' classroom experience. Nonetheless, educational psychologists have spent a lot of time thinking about the implications of cognitive psychology for teachers.[9]

A few publications have come out since 1996 which address the psychology of learning as it applies to adult literacy students:
Adult Learning and Development: Perspectives From Educational Psychology, M. C. Smith & T. Pourchot, Eds. (Erlbaum, 1998).
Bridges to Practice: Guidebook 4—The Teaching/Learning Process, National Adult Literacy and Learning Disabilities Center (Academy for Educational Development, 1999).
Enhancing Learning in Training and Adult Education, R.R. Morgan, J.A. Ponticell & E.E. Gordon (Praeger, 1998).
International Encyclopedia of Adult Education and Training, 2nd Ed., A.C. Tuijnman, Ed. (Pergamon, 1996).

Is this book for me?

This book is meant for three groups of adult educators who teach or tutor reading (including science, literature, and social studies) teaching in GED-level classrooms:

- Trainers of teachers who do initial training or continuing education sessions who are looking for additional training materials
- Staff development professionals who are responsible for teacher training in state departments of adult education and are who are looking for effective approaches
- Teachers or tutors (paid or volunteer) who want to get new ideas for teaching and who have perhaps 30 minutes each Friday afternoon to do a little reading

It may also be useful to ABE reading teachers, math and writing teachers in ABE/GED, as well as job training and English as a Second Language (ESL) teachers and trainers of adults (for example, in computer training, workplace health and safety classes, or health education workshops).

How to use this book

This book has 18 fact sheets on learning and thinking, each about 10 pages long. Each fact sheet can be read by itself, although the summary fact sheets at the end of the book are based on the earlier fact sheets.

The fact sheets themselves incorporate learning methods based on cognitive research:

1. Reflection questions to orient you to the topic and activate your prior knowledge

Questions for teacher reflection

✎Take 15 seconds to write down everything you can think of that is in a kitchen.

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2. Quotes from teachers, learners, and researchers that show how the information is relevant to your teaching

> "Whenever you teach adults something you deprive him or her the opportunity of discovering it."

3. A summary of the ideas and evidence

What we know

What is a Mental Model?

☞Just like your "mental maps" of what is in a kitchen or theater, everyone has many complex models of common things and events in the world. These mental models affect how we . . .

Information that is specific to adult learners is in a special box

> **ADULTS**
> Students who feel they "can't learn" as adults may be comparing their experience of learning as adults with this feeling of learning rapidly as a child.

4. What this means for teachers

What it means for teachers

Using Adult Advantages

🔎 Have discussions that relate the reading to students' experiences. To return to the "Tell-Tale Heart" example, ask students if they have ever done something wrong and felt guilty about it.

5. A set of short lesson ideas (not full lesson plans) based on the findings.

Lesson Ideas

✍ Use any lesson idea from any of the fact sheets in this book that push your students to use a strategy that they have but do not use fluently yet.

You will also find at the end of the book:
- Appendices on two frequently asked questions: Are there learning styles? and What about the brain?
- Short articles summarizing many of the fact sheets, which may be reproduced in teacher newsletters (Please see the copyright information on the inside front cover.)
- A selected bibliography
- A glossary of technical terms used in the book
- An index

I hope that you will find this information both thought-provoking and useful to you in your classes.

Jennifer Cromley, January, 2000

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NOTES

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[1] Cronbach, L.J. (1954). *Educational psychology*. New York: Harcourt Brace, p. 47.

[2] Research is not reported here unless results are significant at the $p<.05$ level or $F \geq 5.00$. The term "average" always refers to the mean.

[3] Purcell-Gates, V. (1997). There's reading . . . and then there's reading: Process models and instruction. *Focus on Basics, 1* (D), 6-10. Retrieved from the World Wide Web on October 12, 1998 from http://hugse1.harvard.edu/~ncsall/vpg.htm. (The address as of February 3, 2000, was http://gseweb.harvard.edu/~ncsall/vpg.htm.)

[4] Resnick, L.B. (1987). Constructing knowledge in school. In L.S. Liben (Ed.), *Development and learning Conflict or congruence?* Hillsdale, NJ: Erlbaum.

[5] Haywood, H.C., & Brooks, P. (1990). Theory and curriculum development in cognitive education. In M. Schwebel, C.A. Maher, & N.S. Fagley (Eds.), *Promoting cognitive growth over the life span*. Hillsdale, NJ: Erlbaum.

[6] Roger Diaz de Cossio, a presenter at the first International Conference on How Adults Learn, held in Washington, DC, in April, 1998, wrote in a postscript to his paper, "I learned many things from the Conference, especially the fact that we are all in the same boat: (a) we do not really know how adults learn." de Cossio, R.D. (1999). Adult education, migration, and immigrant education. In U.S. Department of Education. (1999). *How Adults Learn*. Washington, DC: Author, p. 47.

[7] Smith, M. C., & Pourchot, T. (1998). What does educational psychology know about adult learning and development. In M.C. Smith & T. Pourchot, (Eds.), *Adult learning and development: Perspectives from educational psychology*. Mahwah, NJ: Erlbaum.

[8] Torff, B., & Sternberg, R.J. (1998). Changing mind, changing world: Practical intelligence and tacit knowledge in adult learning. In M.C. Smith & T. Pourchot, (Eds.), *Adult learning and development: Perspectives from educational psychology*. Mahwah, NJ: Erlbaum.

[9] Byrnes, J.P. (1996). *Cognitive development and learning in instructional contexts*. Boston: Allyn and Bacon; Gagne, E.D., Yekovich, C.W. , & Yekovich, F.R. (1993). *The cognitive psychology of school learning* (2nd ed.). New York: HarperCollins; Anderson, J.R. (1995). *Cognitive psychology and its implications* (4th ed.). New York: Freeman.

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Fact Sheet 1: Literature is not Science

Principle: Literature Strategies are Different from Science Strategies

> "I knew from my teacher training that students' skills would be uneven, that they might be good at reading and weak in math. What surprised me was that they could be such good readers in science and such bad readers in literature."—GED teacher

Questions for teacher reflection

- Do you think you are better at literature or math, or do you do equally well at both? Why?
- Do you think that what you learned in social studies class as a child helped you in science? Explain.
- Have you ever done logic puzzles (such as brain teasers)? Do you think they have helped you solve real-life problems in your personal life or at work? Why or why not?
- Have you ever taken a "thinking skills" class. Do you believe it helped you think better? How?

All of these questions got you thinking about whether thinking skills are general or specific to certain subjects.

What we know

Are There General Thinking Skills?

Do you think that people are either generally smart or generally not? Are good chess players also smart in science or languages? Do good writers also do well in math? The debate between those who say that thinking skills are general and those who say they are specific is an old one, and has been particularly fierce for the last 40 years.[1] On one side, people argue that all thinking skills are general; some of them say that schools should therefore teach logic, critical thinking, or problem solving in separate classes.[2] On the other side, some argue that all thinking skills are specific to fields; therefore, some of them say that thinking should only be taught as part of school subjects.[3] The question is complicated because some thinking skills may be general, but have to be taught in specific subjects to be effective.

Research from many fields shows that being "smart" in one area (like literature) does not usually make a person "smart" in other areas.[4] Of course, reading quickly probably helps people in all areas that require reading, and people think much better in familiar topic areas than unfamiliar ones.[5] But many researchers feel that there are very few general thinking or problem-solving skills, and that these cannot be taught directly.[6] The evidence from thinking and problem-solving programs, experts and beginners, child development, anthropology, and brain biology is found below.

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☞ Most thinking skills and problem-solving skills seem to be specific in different subjects.[7] Math thinking skills are useful for math, but not for science. Social studies thinking skills are useful for social studies, but not for literature. Some of these skills may appear to be common but are not. For example, "cause and effect" in social studies is not the same as "cause and effect" in science. Likewise, "survival of the fittest" in biology is not the same as "survival of the fittest" in human society. Although we can put the same label ("cause and effect") on both things, they are not the same. Also, general problem-solving principles recommended by the GED Testing Service like "breaking down a large problem into smaller ones" are very different when applied to science than when applied to math. Students need to be taught how to apply them separately in every subject area. This probably explains why stand-alone general thinking programs (like CoRT, IDEAL, Odyssey, or Instrumental Enrichment) do not significantly improve students' standardized test scores overall.[8]

☞ Because most teachers have had 16 or more years of formal education and have developed general problem-solving strategies, it may be hard to appreciate how different the thinking skills are in each of the subject areas. But consider the table below:[9]

Subject	**Sample subject-specific information**	**Sample subject-specific problem-solving strategies**	**Sample problem**
Economics	Supply and demand. Relationship between taxes and employment. Relationship between inflation and production .	Effect of government policies on businesses. Calculating profitability.	Which of the following would be an effect of raising the minimum wage?
American history	Basic names, dates, and facts about events. Trends in American history (urbanization, industrialization, etc.). Geography.	Historical cause-and-effect. Multiple points of view and interpretation in history. Interpreting historical actions in terms of interests and motives.	Which of the following arguments explains the settlement pattern for the western states shown on the map?
Chemistry	The elements. Chemical bonds. Chemical reactions	Naming compounds. Balancing chemical equations. Calculating concentrations.	What will be the product of $CH_4 + O_2$?
Literature	Structure of a story. Forms (poems, plays, novels, etc.). Names, works, and significance of prominent authors.	Understanding figurative language. Inferring motives of characters. Interpreting the author's purpose.	Why does the character tell the joke about the salesman?

Rochel Gelman even feels that "the languages of science and mathematics are better thought of as different languages than the one we use in everyday talk."[10]

☞ It is possible to help students transfer what they have learned in one class to another class or to the world outside of school. This is covered in Fact Sheet 2, Making Connections, which includes analogies.

Evidence From Thinking And Problem-Solving Programs

☞ Hundreds of studies of thinking and problem-solving programs show that people only improve on the type of problems they learn in the programs.[11] In programs that use logic problems to teach thinking, people become better at solving logic problems. But they do not become better at math or become better thinkers overall. In fact, in most of the studies, students' standardized test scores did not go up overall.

☞ According to researchers:

- "The available evidence does not establish that such [general thinking] courses can produce broad transfer of learning."[12]
- "Are there general problem-solving methods that transfer broadly across content domains and can be taught? A long line of research (starting with the work of Thorndike and James) casts a gloomy pall on the prospect of general transfer."[13]
- "Significant gains . . . show up only on tests that are highly similar to the curricula in content and structure."[14]
- "Generalized thinking ability, that is, processing ability not tied to a particular intellectual skill, must be inductively derived [figured out] by students as incidental learning [by trial and error] over years of practice."[15]
- "There is no strong evidence that students in any of the . . . thinking-skills programs improved in tasks that were dissimilar to those already explicitly practiced."[16]
- "Previous attempts to teach students to become better thinkers have not always turned out to be well-documented successes."[17]
- "[Identifying] the teachable aspects of problem solving . . . has a long and somewhat disappointing history."[18]

☞ So what do the studies show? There are several consistent findings:

1) Teaching thinking skills is most effective in the context of **real problem-solving in a particular field**. To learn to think, you have to have something to thing about! To teach comparing and contrasting in social studies have students learn about two wars and then compare and contrast them.[19]
2) Teachers need to **demonstrate** or model for students the **process** of solving a problem in that field. To teach cause and effect in science, talk out loud as you solve a physics problem, such as what happens when one object hits another object.[20]
3) Effective teachers create real **discussions** among students and between students and the teacher. Students learn to think by actively thinking and engaging with the subject in a social setting. To teach students to look at both sides of an argument in history, have a debate[21] or ask student to write from another person's point of view.

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4) Effective programs identify the **kinds of problems** students must be able to solve, and teach students how to solve those problems. To teach students how to infer meaning from context in poetry, have them read poems and discuss them.[22]

☞General problem-solving strategies are too general for most students to apply. For example, a study strategy called MURDER (Mood, Understand, Recall, Detect, Elaborate, and Review) asks students to detect "omissions, errors, and ways of organizing the information."[23] The type of omissions or errors will be different in a math problem, an economics question, a literature analysis, and so on. So a student needs to already understand, for example, what a good argument is in economics, in order to use this strategy to study economics. While the strategy can help a student in any subject, it does not automatically work for a given subject until the student gets to know the field. So the results of trying to teach thinking skills show that skills should be taught explicitly as part of science, social studies, math, and other subject areas. Skills that are learned in one area do not automatically transfer to another area, and students need a lot of specific knowledge in order to be good thinkers in a subject.[24]

Evidence From Experts And Beginners

☞Expert chess players are no better at science, math, or other subjects than the average adult. Expert chemists are no better at solving political science problems than college students are.[25] People who are expert at memorizing numbers are no better than average at remembering letters. Being an expert generally means being an expert in one subject. Of course, many people develop other skills while becoming an expert. For example, doctors learn how to memorize medical terms in medical school, so they probably know how they memorize effectively.

☞Being an expert includes knowing a lot of facts in a subject (like knowing the parts of speech), knowing many rules (such as grammar rules), knowing when to use those rules (for example, knowing that capitalization rules only apply to the beginning of a sentence or a proper noun). In other words, experts are not people who are good at problem solving who just happen to apply it to whatever field they are in. **Experts have more subject knowledge** and, along with many problem-solving techniques, they know when to use those techniques.[26] "General strategies per se are not the deciding factor in . . . an expert's superior performance; rather, it is the application of a general strategy to a well-organized knowledge domain."[27] Experts have also solved problems in their field so often that the process is faster for them[28] (see Fact Sheet 13: What Does Good Thinking Look Like? for more information).

Evidence About Specialized Areas Of The Mind

From Child Development[29]

☞*How Things Move*—Even very young infants (6-10 months old) seem to understand the difference between animals that can move on their own and non-living objects that cannot. We know this because they stare for much longer at objects that move on their own (but should not), than at animals. This ability seems to be inborn. It is different from understanding which things are breakable, what makes a noise, and other knowledge that children learn as they play.[30]

Common sense ideas about how things move are not the same as the laws of physics. For example, in physics, objects in motion tend to remain in motion. But in real life, everything that moves eventually stops moving (physicists explain that this is because of friction). But even college students with years of physics classes fall back on this child-like "naïve physics" when they are not in physics classes. Inborn ideas about how things move are separate from ideas about biology or how people behave.[31]

☞ *Language*--All children seem to have from birth the ability to learn a language. They are not programmed to learn any specific language, but they have a language capacity that helps them learn the language that is spoken (or signed) around them. This language capacity is not the same as a reading capacity, writing capacity, or other abilities. It is a separate "module" in the mind that does not have to be learned, we are born with it.[32]

☞ *Math*--Very young infants (even as young as 5 months old) seem to understand the difference between one object and more than one object. Again, we know this because they stare for much longer when there is an unexpected number of objects than when there is the expected number.[33] Again, this ability seems to be inborn, and it is different from counting, which children must learn.[34]

From Anthropology

☞ Every culture that anthropologists have studied has a similar way of organizing the animals in that culture. Mayan Indians in Central America and students in Michigan organize familiar animals in the same way (about 75% agreement). For example, both groups separate mammals from non-mammals and people from all other animals.[35] Other parts of the two cultures are not similar. So there seems to be a part of the mind that is "hard wired" to classify animals, and that is different from other kinds of classifying.

From Brain Biology

☞ Parts of the mind are specialized for different skills, like vision, language, speech, hearing, seeing faces, and touch. For example, information that comes through your eyes is processed by one part of your mind. Sounds are processed by another part. Information from your eyes cannot be processed by the language area of the mind. Evidence from patients with brain damage suggests there may also be areas specialized for music, number, and social interactions.[36]

ADULTS

Adults' skills tend to be more uneven than children's. While we do not expect a second-grade child's reading and math scores to be very far apart, this is common in adults. One reason may be that adults have had more time to improve the skills they are good at, while the skills they are not good at have stagnated. For example, people who read a lot continue to improve their vocabulary and knowledge of the world even after school; those who do not read do not improve those skills.[37]

☞There are a few general skills, but they are always used within a subject area.[38] Skills learned at school will be specific to different subjects, unless teachers make the connections between different subjects for students. This is the subject of Fact Sheet 2, Making Connections.

Summary

1. Chess masters are not any "smarter" in other subjects (like literature, science, or math) than anyone else. Experts tend to be very good in only one subject.
2. Each subject has unique bodies of knowledge, types of problems, and problem-solving techniques.
3. We have twenty years of failed "general problem solving" programs.
4. General strategies need to be practiced in each subject area.
5. Why?—Converging evidence from four areas: Expert/novice.
6. Child development—inborn language, number, and motion concepts.
7. Anthropology—common ways of categorizing animals.
8. Brain—Visual information cannot be processed in language areas.
9. Teachers need make the connections between different subjects for students.

What it means for teachers:

Student Abilities

- Do not assume that a student who is good in one subject will be good at another or that a student who is poor in one subject will be poor in others.

- Do not assume that a student who learns a skill in your class (like finding the main idea in history) will be able to apply the same skill in another subject (like finding the main idea in science).

Setting Learning Objectives

- Set very specific teaching objectives including the types of problems you want students to be able to solve. Then teach them how to solve those problems.[39]

Teaching Content

- Teach more facts! Students cannot think if they do not have anything to think with and connect new information to.

- Teach your students to use the terminology, symbols, and diagrams that are used in your subject.[40]

Teaching Thinking Strategies

- Teach problem-solving strategies (like the ones on page 2) and how to use them in the context of particular subject matter. (See Fact Sheet 4 for a detailed description of how to teach strategies.)

- Balance facts and problem-solving strategies in your subject. Be clear about how the strategy is applied in your subject.

- Give worked-out problems that show how thinking and problem solving work in your subject.[41]

- Mix up problems of different types (such as main point and author opinion questions) rather than lumping all of one type of problem together.

- If you want students to be able to solve real-life problems, such as consumer math, then teach those problems in addition to the type of problems students are more likely to see on tests.[42]

- Do not use activation of prior knowledge or analogies with students who do not have background knowledge in that topic.

Lesson Ideas

Intelligence

- Ask students to write about what they think about intelligence. Do they think people are born "smart" or "dumb"? Do they think people who are good at science are always good at math? Do they think people who are "book smart" are also "street smart"?

Subject Areas

- Over a school term, expose your students to the core ways of thinking and ways of making an argument in your subject. For example, in history, be sure to cover acceptable types of evidence (speeches, newspapers, novels, maps, laws, letters, hearsay), cause and effect in history (it is not the same as in science!), types of patterns (population, employment, voting), and so on. Group projects are an interesting and engaging way to do this.

- Over a school term, expose your students to the core problem-solving strategies and tools in your subject. For example, in GED economics, be sure to cover patterns and correlation (when wages go up, employment goes down); using graphs, tables, and charts; measuring employment, wages, tax rates, and so on. Again, group projects are an interesting and engaging way to do this.

- Ask students to solve a simple problem in a subject they know a lot about. Then ask them to solve a problem that uses the same skills but in a subject they do not know about. (Unscrambling a word they know and one they do not know is probably the simplest example.)

Show students that a lot of "smarts" is not just raw brain power but knowing something about the subject!

✍To build students' vocabulary in your subject, choose the most important terms (for chemistry, terms like atom, molecule, electron, proton, and so on) and have students use them in many different types of exercises. Make matching column exercises; fill-in-the-blanks; play word games like hangman, unscramble letters, and so on. Students need to use the terms in a context.

✍Ask students to write in their social studies, science, and literature classes using a type of argument or strategy that is used in that field. For example, ask biology students to write about the differences between plants and animals. The best way to master a subject is to have to explain it to someone else. Focus your comments on the arguments and evidence used. If you comment on grammar, do it separately.

NOTES

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[1] Brown, A.L., Bransford, J.D., Ferrara, R.A., & Campione, J.C. (1983). Learning, remembering, and understanding. In J.H. Flavell & E.M. Markman (Eds.), *Handbook of child psychology: Vol. III. Cognitive development*, pp. 126-129, 141. New York: John Wiley & Sons.

[2] Among many researchers taking this position are Simon, H.A. (1976). Identifying basic abilities underlying intelligent performance of complex tasks. In L.B. Resnick (Ed.), *The nature of intelligence*. Hillsdale, NJ: Erlbaum. Others include Plato, Piaget, and Halpern, D. (1993). Assessing the effectiveness of critical-thinking instruction. *JGE: The Journal of General Education, 42* (2), 239-254.

[3] Singley and Anderson call this the "radical specificity" position—there are no general thinking skills (Singley, M.K., & Anderson, J.R. (1989). *The transfer of cognitive skill*. Cambridge, MA: Harvard University Press, p. 235). Singley and Anderson mention D'Andrade (1982), Griggs & Cox (1982), and Thorndike (1913) as proponents of this position. Supporters of a modular model of the mind, who may or may not argue for thinking skills classes, include Flavell and Gelman, R. (1991). Epigenetic foundations of knowledge structures: Initial and transcendent constructions. In S. Carey & R. Gelman (Eds.), *The epigenesis of mind: Essays on biology and cognition*. Hillsdale, NJ: Erlbaum. In the middle of the road (there may be general skills, but they need to be taught in the context of subject matter), interestingly, are both E.D. Hirsch (a conservative) and Howard Gardner (a liberal). Others include Perkins & Salomon, and M.J. Adams.

[4] Perkins, D.N. & Salomon, G. (1988). Teaching for transfer. *Educational Leadership, 46* (1), 22-32. This is true even though people who score high on one part of an IQ test are likely to also score high on other parts of the same IQ test.

[5] Brown, A.L. (1990). Domain-specific principles affect learning and transfer in children. *Cognitive Science, 14*, 107-133.

[6] Bransford, J.D., Arbitman-Smith, R., Stein B.S., & Vye, N.J. (1985). Improving thinking and learning skills: An analysis of three approaches. In J.W. Segal, S.F. Chipman, & R. Glaser (Eds.), *Thinking and learning skills: Vol. 1 Relating instruction to research*. Hillsdale, NJ: Erlbaum, and Gelman, R., & Baillargeon, R. (1983). A review of some Piagetian concepts. In J.H. Flavell & E.M. Markman (Eds.), *Handbook of child psychology: Vol. III. Cognitive development*, New York: John Wiley & Sons, p. 210.

[7] Chipman, S.F., & Segal, J.W. (1985). Higher cognitive goals for education: An introduction. In Segal et al. (Eds.), *Thinking and learning skills* and Goldman, S.R., Petrosino, A.J., & the Cognition and Technology Group at Vanderbilt. (1999). Design principles for instruction in content domains: Lessons from research on expertise and learning. In F.T. Durso, R.S. Nickerson, R.W. Schvaneveldt, S.T. Dumais, D.S. Lindsay & M.T.H. Chi (Eds.), *Handbook of applied cognition*, New York: John Wiley & Sons.

[8] Perkins, D.N., & Salomon, G. (1989). Are cognitive skills context-bound? *Educational Researcher, 18* (1), 16-25.

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[9] Some examples are from Resnick, L. (1987). *Education and learning to think.* Washington, DC: National Academy Press, p. 18 and Leinhardt, G. (1992). What research about learning tells us about teaching. *Educational Leadership, 49* (4), 20-25.

[10] Gelman, Epigenetic foundations of knowledge, p. 320.

[11] Chance, P. (1986). *Thinking in the classroom: A survey of programs.* New York: Teachers College Press.

[12] Resnick, *Education and learning to think,* p. 35.

[13] Singley & Anderson, *The transfer of cognitive skill,* p. 230.

[14] Adams, M.J. (1989). Thinking skills curricula: Their promise and progress. *Educational Psychologist, 24* (1), 25-77.

[15] Derry, S.J., & Murphy, D.A. (1986). Designing systems that train learning ability: From theory to practice. *Review of Educational Research, 56* (1), 1-39.

[16] Bransford, et al., Improving thinking and learning skills, p. 202.

[17] Mayer, R.E. (1988). Teaching for thinking: Research on the teachability of thinking skills. In *The G. Stanley Hall Lecture Series, 9,* 139-164.

[18] Mayer, R.E. (1992). *Thinking, problem solving, cognition* (2nd ed.). New York: W.H. Freeman, p. 363.

[19] Byrnes, J. (1996). *Cognitive development and learning in instructional contexts.* Boston: Allyn and Bacon, 1996, p. 69-74 and Resnick, *Education and learning to think.* A growing field called "situated cognition" studies how thinking is based in particular situations. For example, some people can use math very well in grocery stores and not very well in paper and pencil exercises. Their math skills are situated in the grocery store context. In the same way, a lot of school learning is situated in classrooms so it does not transfer well outside of the classroom. See Brown, J.S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18* (1), 32-42 and Rogoff, B., & Lave, J. (Eds.). (1984). *Everyday cognition: Its development in social context.* Cambridge, MA: Harvard University Press.

[20] Mayer, Teaching for Thinking. Richard Prawat disagrees with explicitly teaching thinking strategies. He argues for an immersion approach where students practice real thinking tasks, but teachers do not explicitly instruct in how to think, even in the domain (Prawat, R. (1991). The value of ideas: The immersion approach to the development of thinking. *Educational Researcher, 20* (2), 3-10, 30).

[21] Brown et al., Situated cognition and the culture of learning.

[22] Mayer, R.E. (1987). *Educational psychology: A cognitive approach.* Boston: Little, Brown, p. 214.

[23] Slavin, R. (1997). *Educational psychology: Theory and practice* (5th ed.). Boston: Allyn and Bacon, p. 208.

[24] Alexander, P.A., & Judy, J.E. (1988). The interaction of domain-specific and strategic knowledge in academic performance. *Review of Educational Research, 58* (4), 375-404 and Keil, F.C. (1991). The emergence of theoretical beliefs as constraints on concepts. In S. Carey & R. Gelman (Eds.), *The epigenesis of mind: Essays on biology and cognition,* Hillsdale, NJ: Erlbaum.

[25] Glaser, R., & Chi, M.T.H. Overview. (1988). In M.T.H. Chi, R. Glaser & M. Farr (Eds.), *The nature of expertise.* Hillsdale, NJ: Erlbaum.

[26] Derry & Murphy, Designing systems that train learning ability.

[27] Modeling Expertise. Chapter 4 in Druckman, D., & Bjork, R.A. (Eds.). (1991). *In the mind's eye: Enhancing human performance.* Washington, DC: National Academy Press.

[28] Glaser & Chi, Overview.

[29] Gelman & Baillargeon, A review of some Piagetian concepts.

[30] Carey, S., & Spelke, E. (1994). Domain-specific knowledge and conceptual change. In L.A. Hirschfeld & S.A. Gelman (Eds.), *Mapping the mind: Domain specificity in cognition and culture,* Cambridge: Cambridge University Press.

[31] Perkins & Salomon, in Teaching for transfer, make the important point that domains in the mind do not correspond closely to school subjects. Causality in history and causality in "current events" are fundamentally the same even if they are discussed in different classes in schools.

[32] Noam Chomsky's domain-specific language theory is explained in Hirschfeld, L.A., & Gelman, S.A. (1994). Toward a topography of mind: An introduction to domain specificity. In Hirschfeld & Gelman, *Mapping the mind*

[33] Wynn, K. (1992). Addition and subtraction by human infants. *Nature, 358,* 749-750.

[34] Gelman, Epigenetic foundations of knowledge.

[35] Atran, S. (1995). Classifying nature across cultures. In E.E. Smith & D.N. Osherson (Eds.), *An invitation to cognitive science: Vol. 3. Thinking* (2nd ed.). Cambridge, MA: MIT Press.

[36] Leslie, A.M. (1991). ToMM, ToBy, and agency: Core architecture and domain specificity. In Hirschfeld & Gelman, *Mapping the mind.*

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[37] Stanovich, K.E., West, R.F., & Harrison, M.R. (1995). Knowledge growth and maintenance across the life-span: The role of print exposure. *Developmental Psychology, 31* (5), 811-826 and Smith, M.C. (1990). The relationship of adults' reading attitude to actual reading behavior. *Reading Improvement, 27* (2), 116-121.

[38] Perkins & Salomon, Are cognitive skills context-bound?

[39] Brainin, S.S. (1985). Mediated learning: Pedagogic issues in the improvement of cognitive functioning. In E.W. Gordon (Ed.), *Review of Research in Education, 12*, 121-155.

[40] Nickerson, R.S. (1994). The teaching of thinking and problem solving. In R.J. Sternberg (Ed.), *Thinking and problem solving*, San Diego, Academic Press.

[41] Mayer, *Thinking, problem solving, cognition*, pp. 439-452.

[42] Resnick, L.B. (1987). Learning in school and out. *Educational Researcher, 16*, 13-20.

Fact Sheet 2: Making Connections

Principle: Show Students How to Use Old Skills in New Areas

A student is in charge of sales at the School Store at her GED program one evening.

Teacher: Delores, you know how to do decimals. You just added up the bill and figured out the change.

Student: But that's money, that's not math class!

Questions for teacher reflection

- When have you ever used what you learned in one part of a class to solve a problem later in the same class? (for example, using what you know about fraction word problems to solve decimal word problems)
- When have you ever used what you learned in one subject to solve a problem later in another subject? (for example, using deduction in science to solve a deduction problem in social studies)
- When have you ever used what you learned in school to solve a problem outside of school? (for example, using the writing skills you learned in school to write a letter to your grandmother)
- When have you seen students not be able to solve a problem outside of school that they could solve in class?
- When have you seen students be able to solve a problem outside of school that they could not solve in class?

These questions got you to think about **transfer**—using what you know in one area to solve a problem in another area.

What we know

The Need For Transfer

☞The ability to apply information or skills learned in one situation to another situation is a very important one.

- Schools expect students to transfer what they learn in the classroom to their lives at home, work, and as citizens and community members. According to one researcher, "The question of transfer is perhaps the fundamental educational question."[1]
- Employers expect their employees to transfer what they have learned at school and at previous jobs to the workplace.[2] As technology and work organizations change, employers expect people to use what they know from past experience to perform in a new setting.[3]
- Transfer is also vitally important for the GED. The authors of the GED specifically test students on their ability to "use information and ideas in a concrete situation . . . . in a context different from the one in which they were initially presented."[4] In addition, because the GED tests "critical thinking skills,"[5] students also have to be able to apply skills such as reading

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comprehension to a wide range of reading materials (social studies, science, literature, math, written passages on the grammar test, test directions, and the questions themselves).
- As teachers, I believe we expect students to transfer skills from one class to another. For example, if they have learned to become good critical readers in science, we expect them to show that critical reading in their social studies classes too.

However, transfer is a very difficult skill that has rarely been found in psychology research.[6] (See Fact Sheet 1: Literature is Not Science for some reasons why transfer is hard to find.)

☞ In a classic study on people's difficulty with transfer, college students read a problem (with the solution) about a doctor who needed to destroy a tumor in a sensitive area. The doctor beamed many low-intensity rays at the tumor from many directions. Then the students read a problem about an army trying to attack a fortress surrounded by many small roads with land mines on them. The solution to the problem was to split up the army into small groups that would not trip the land mines and attack the fortress from many directions at once. About 80% of the students could not transfer the solution of the first problem to the second one without a hint.[7]

☞ Adults who could do "grocery store math" with 98% accuracy only got 59% of the same kind of questions right on a paper-and-pencil test.[8] They could not transfer their math knowledge from the grocery store to the test because they did not see that the two tasks were the same.

☞ The most difficult part of transfer is "seeing" when a problem that you know how to solve can help you solve the new problem you are facing.[9] In the grocery example above, adults failed to see that the grocery store math they knew how to do could help them solve the paper-and-pencil problems they were not sure how to do.[10]

☞ Clearly it is easier to transfer knowledge when the subject matter is very similar.[11] A student who learns to capitalize cities will have an easier time capitalizing states than capitalizing personifications. Transfer is also easier when students do not have a competing mental model.[12] For example, students will have trouble applying school learning about evolution when they are at the zoo if they have a competing creationist model. Finally, transfer is easier for more general knowledge.[13] Ideas that are associated with only one field (like democracy in social studies) will be harder to transfer than ideas that apply very generally (like large organisms or groups being more powerful than small ones).[14]

How Does Transfer Happen?

☞ Despite the pessimistic research, good learners do transfer more than poor learners (learning disabled students tend to have even more difficulty with transfer).[15] James Byrnes suggests six things that can help students transfer knowledge:

1. Using the skill in several contexts (adding in class and adding at the "school store")
2. Knowing when to apply the skill (capitalization rules always apply at the beginning of a sentence and in the middle of a sentence they only apply to proper nouns)

3. Learning new facts through patterns (enough and rough are spelled like tough)
4. Learning for understanding (knowing why the American colonists went to war against Britain)
5. Trying to solve the problem by applying your understanding (if cats are mammals, then dogs must be mammals too)
6. Having realistic ideas about learning (knowing that mistakes are part of learning)[16]

This can be described as a "teaching for transfer" approach.[17] Ironically, "teaching for transfer" may lead to students performing worse at first, but later performing much better.[18]

Teach Skills In Multiple Contexts

☞ One approach to transfer is to teach skills in several different contexts. For example, if students are learning proofreading, they can proofread a class flyer, a newsletter, a business memo or resume cover letter, and so on. Another approach is to identify all of the situations where students could use the skill and teach them specifically how to use it in that context. For example, construction apprentices could learn to add fractions for measuring boards in inches, (and other one-dimensional measurements), plywood in square feet (and other two-dimensional measurements), and cement in cubic yards (and other three-dimensional measurements).[19]

☞ Sometimes the same skills are applied differently in school situations and outside of school.[20] For example, math word problems use language that is not found outside of school ("Bill has four more marbles than Jane.")[21] Teaching the same problems in "real world" language can help students bridge the gap from real life to school questions. It also helps students do better on standard math word problems.[22]

Teach When To Use The Skill, Not Just How To Do It

☞ Students who know when to use a skill, as well as how to do it, will also be better able to apply it in a new setting.[23] For example, a student who knows that gravity acts on all objects on the earth will know that gravity acts on amusement park rides, not just on falling objects in physics class. When skills are taught in school, teachers rarely tell students when to use the skill and when it does not apply.

☞ One of the biggest problems students face is not recognizing that they can apply a strategy that they already have. Teaching skills in multiple contexts may help this problem.[24] A student who learns how to use a dictionary to look up unknown words in science and literature and social studies is likely to think that a dictionary may also be helpful for an unknown word in a writing class.

☞ Experts know when to use skills more than beginners do, and they use strategies more automatically. For example, a 12th grader may add fractions more quickly than a 6th grader because the 12th grader can simply multiply the denominators faster, not because the 12th grader has more advanced math knowledge.[25]

Teach Through Patterns

☞ Students who learn new facts through patterns or principles (all even numbers end in 0, 2, 4, 6, or 8), rather than by rote, are better able to transfer that knowledge. For example, a student who has to learn about each even number one at a time (18 is even and 62 is even and 26 is even, and so on) may never be able to conclude that 34 is also even. Another example is learning to read words through patterns. A student could learn hat, mat, and cat by sounding out each one, or could sound out "hat" and then learn that "cat" and "mat" are just like "hat." In one study, students who learned what went on inside a computer's memory were able to transfer their learning from one computer program to another much better than students who had not learned what went on inside.[26]

Teach For Understanding

☞ Having a deeper understanding of a topic helps students transfer.[27] For example, adults who learned how to use a word processing program and understood why they needed to take certain steps could transfer that learning to another word processing program.[28] In another study, changing surface rules for a game of bridge did not change how well experienced bridge players could play, but changing fundamental rules did make them play worse.[29]

☞ Students often learn facts in a disconnected way and do not learn for understanding.[30] In one study of social studies knowledge, 51% of 5th graders knew something about the Declaration of Independence, but only 26% knew that it was England that the U.S. declared itself independent from.[31] Part of the problem, of course, is that many teachers do not teach for understanding. Teaching for understanding takes longer than teaching by rote.[32] Experts, on the other hand, tend to have very well-connected knowledge (not just more knowledge).[33]

☞ In order to transfer learning, students have to have a very good understanding of the subject they are transferring from. For example, before asking students to use World War I to understand World War II, make sure they understand World War I. It is not, however, necessary to master all aspects of the fundamentals in a subject area before you can do any transfer. For example, as soon as students can understand a passage, you can have a discussion about what it means. They do not have to become expert decoders before you can ever work on comprehension. Active learning, lots of practice, learning for understanding, feedback, and well-organized texts can help students build a solid foundation.[34]

☞ Students who spend time organizing what they know—by writing outlines, bubble diagrams, summarizing, or other methods—have a deeper understanding of what they have learned. Students who also relate what they are learning to what they already know have a deeper understanding. Students who both organize the information they are learning and integrate it with what they already know understand much better than students who do not.[35]

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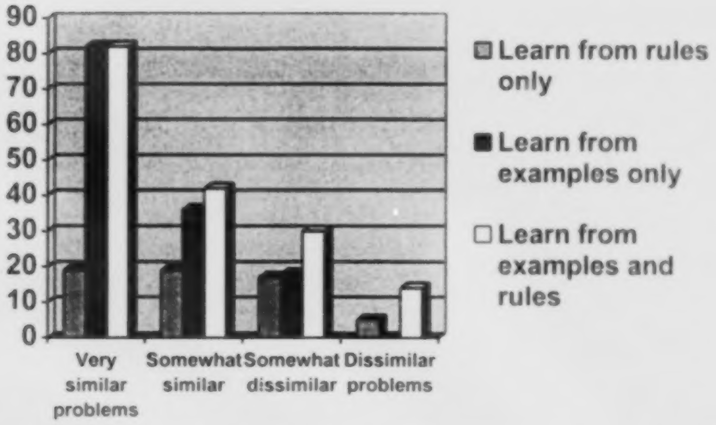
Is It Better To Learn From Rules, Examples, or Both?



School learning tends to use explanations and rules, rather than examples. When a new problem is like an old problem, students who learn from examples can transfer well. The more unlike the example is, the less well the students do. When students learned from rules alone and never had examples, the percentages were miserable, all less than 20%. With examples and rules, the students did better, even on unlike problems.[36]

Students Need To Apply Their Understanding When Solving Problems

Applying a principled understanding is another important part of transfer.[37] For example, a student who tries to answer a question about a poem by understanding the poem will do better than one who tries to remember, "Now, what was the answer to this question the last time I saw it?"

Students Need Realistic Ideas About What Learning Is

Students are more likely to transfer if they know that learning is about understanding, not just memorizing facts. For example, a student who actively tries to understand what she reads will remember more than one who reads to "say the words right." The one who reads for understanding can apply her background knowledge (for example, knowledge about gravity) in new areas (such as plant roots growing down).

Teaching With Analogies[38]

In order to apply information in a new setting, students need to see the relationship between the two situations. For example, if a student is going to use what he knows about the World War II to understand the Gulf War, he needs to make the connections between:

World War II	⇔	Gulf War	⇔	Role
Germany	⇔	Iraq	⇔	Aggressor nation
Hitler	⇔	Saddam	⇔	Dictator
Czechoslovakia	⇔	Kuwait	⇔	Innocent country invaded by aggressor.[39]

☞One way to teach for transfer is to use analogies like this and explain to students what makes the two situations the same. Different analogies can explain different aspects of a problem. For example, to explain electricity, some teachers use the analogy of water in pipes and some use the analogy of cars moving in a road. Less water moves through a small pipe, just like less current moves through a small wire. Fewer cars can get through a narrow road. The smallness of the pipe causes the reduction in flow. The narrowness of the road causes the drop in the number of cars getting through.[40] Students who learned the water analogy did better on electricity questions about batteries (and worse on questions about resistors). Students who learned the cars analogy did better on electricity questions about resistors (and worse on questions about batteries).[41]

Electricity	⇔	Water	⇔	Driving
Electrons	⇔	Water	⇔	Cars
Resistor	⇔	Narrowed pipe	⇔	Narrowed road
Resistance	⇔	Pipe narrowness	⇔	Road narrowness
Current	⇔	Water flow	⇔	Cars getting through[42]

Students seem to learn better when they see many analogies, especially if the analogies are different from each other, such as the water and car analogies above.[43] Students start to see which parts of the situation are important and which ones are just surface differences.

ADULTS

Adults have some more experiences to make analogies from than children do. For example, they may know about car engines, electricity, work, city politics, and so on. Keep in mind, though, that many adult literacy students have a very narrow range of experiences. For example, they may ride the bus, but not the subway.

Teaching From Examples

☞Another way to teach for transfer is to use many worked-out example problems and help students see what they have in common. Sample problems work particularly well for students who are beginners on a particular skill.[44] As mentioned earlier, school learning tends to use explanations and rules, but when children learn from their parents, they tend to learn from examples, which clearly is an effective way to learn and teach.[45]

☞In one study, students learned better from, for example, seeing 4 worked-out problems and doing 4 practice problems, than from seeing one worked-out problem and doing 8 practice problems.[46] Surprisingly, students can get a better understanding of math problems by using many worked-out problems than from being lectured to. Teaching from examples is not just rote learning—theories are easier to understand in the context of a real problem than in the abstract. Xinming Zhu and Herbert Simon have designed an algebra and geometry curriculum that can be taught in only 2 years (instead of 3) to average Chinese middle school students by teaching from examples.[47] Worked-out examples can help low-scoring students do as well as high-scoring students on math problems.[48]

Summary

1. Teach skills in multiple contexts.
2. Teach when to use the skill, not just how to do it.
3. Teach through patterns.
4. Teach for understanding.
5. Students need to apply their understanding when solving problems.
6. Students need realistic ideas about what learning is.

What it means for teachers

Transfer

🔑 Always give problems that have a context.[49] For example, make all grammar problems proofreading problems, so that students can see where they need to use the skills they are learning.

🔑 Imagine the transfer you want students to make and teach in a way that helps students make those connections.[50] To do this, you will have to look closely at what skills and knowledge are needed for the initial learning and for the later transfer.[51]

🔑 Mixing up types of practice problems (like mixing up comprehension and analysis questions) improves transfer later.[52] Students do not get into a habit of blindly using one strategy, but have to choose strategies based on understanding the problem.[53]

🔑 Start with the skills that students do have to teach new skills.[54] For example, reasoning about what to say to a landlord (tactfully and indirectly) may help students understand an indirect conversation in a literature passage.

🔑 When you introduce new information, explain how it could apply in students' lives (now or in future careers) or ask students how they think it can be useful.[55]

Modeling

🔑 To help students transfer from one area to another (for example, to transfer writing skills from school to home), demonstrate how you would make that transfer. Then ask students to transfer the knowledge themselves.[56]

🔑 Simply telling students to transfer is not effective until they have some examples.[57]

🔑 Point out what two different situations have in common, for example, the treatment of Blacks before the Civil War and in South Africa in the 1980s. Most teaching tends to cover the features that make each situation stand out, not what they have in common.[58]

Analogies

- Be sure that your students know the topic you are making an analogy from. For example, using "Fore!" in golf as an analogy to teach "Timber!" in forestry would be a bad example (unless your GED students play golf).

- When you make an analogy, explain in detail how the parts of each example relate to each other.[59] In other words, say "The earth circles around the sun. An electron circles around the nucleus," rather than, "An electron is like the earth."

- You may need to explain that analogies are about how the parts of each situation relate to each other, not how the situations relate. When we say "Cat is to kitten as horse is to foal," we do not mean that horses are like cats![60]

- Begin your explanation with the familiar example. In other words, say "The earth circles around the sun. In an atom, the electrons circle around the nucleus," rather than, "An electron circles around the nucleus just like the earth circles around the sun."

- Also point out the differences between the two situations. In the sun example, the sun is yellow, hot, and huge. The earth has life on it. These aspects of the sun and earth are not relevant to the nucleus and electrons.[61] It is better to start from a rich example that many sample problems can be compared to.[62]

- Newspapers often use language that depends on analogies, such as "sour grapes" (which refers to a story from Aesop—the newspaper story is an analogy to the Aesop story). Explain these cultural references so that students can understand the point being made by the writer.[63]

- Students may make an analogy to life experiences that do not match the problem you are working on. For example, they may think about drinking laws as an analogy to voting laws. For drinking laws, "If you're over 21, you can drink or not drink, it doesn't matter." But for voting laws, "If you're over 18, you can vote or not vote, it doesn't matter" is a different kind of statement.[64]

Examples

- Choose examples that are enough alike that students can see the common elements, but different enough that they are not solved in exactly the same way.[65]

- Put example problems in order from easier (more fundamental) to harder.[66]

- Explain why you use the strategies you do on example problems.[67] For example, if you give sample sentences where a colon is used, explain that the colon is there because a list follows.[68]

- Always give examples whenever you teach an abstract idea (like democracy, fractions, verbs, etc.).[69]

🔑 In beginning algebra, use letters that stand for some real quantity, like *s* for speed or *t* for time.[70]

🔑 The risk of learning from examples is that students will simply duplicate the steps from a sample problem without thinking about what it means. You need to explain why you take each step in a sample problem.[71]

Practice

🔑 Allow students to practice some without immediate feedback so that they become more independent learners. This will help them transfer later.[72]

Learning For Understanding

🔑 Ask "Why?" Why do you think the North and the South went to war? Why do you think other countries send diplomats to the United States? I agree that that's the right answer, tell me why you chose it. Why do you think fractions must have the same denominator before you can add them? Why do you think the rich are rich and the poor are poor?

🔑 Ask students to predict what will happen in an experiment, run the experiment, and ask them to account for what happened. This can help them transfer their learning to other areas.[73]

🔑 Students need to first learn concretely, so they can really understand, and then generalize what they have learned.

Lesson Ideas

Teaching For Understanding

✍ Always ask students to write about what they read, it will help them understand it better.

✍ Before reading a story, ask students to role play an analogous story from a familiar setting. For example, before you read *Romeo and Juliet*, ask students to take the roles of 1) a young man and 2) a young woman from rival gangs who fall in love, 3) the man's father, 4) his friends, and 5) the man's mother. Afterwards, discuss what happened and relate it to the story you will read.

✍ Ask, "How is a candle like a light bulb?" and other questions that get students to look at fundamental relationships.

Transfer Across School Topics

✍ Collaborate with other teachers at your school to teach a unit across several subjects. Math problems can apply to social studies/economics. Physics and math go well together.

Real-life Applications

✍For writing lessons, write real-life letters to:

- employers (a cover letter for a job),
- landlords,
- stores, or
- politicians.

✍ Do class projects to go with existing word problems. Use

- fabric, wood, or recipes (for fractions) or
- play money or metric rulers (for decimals).

Design, buy, and make curtains, a skirt, cookies, a bookshelf, or make change to show students that these classroom skills can be useful in a real-life context.

✍Set up a "school store" and have students figure out per item costs, set prices, and calculate profits. This can also be turned into a graphing exercise. Students can also write their own word problems that the whole class will solve.

✍Teach students how to punctuate a letter, then have them write addresses on an envelope and a postcard to show them that the punctuation is the same.

NOTES

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[1] Singley, M.K., & Anderson, J.R. (1989). *The transfer of cognitive skill.* Cambridge, MA: Harvard University Press, p. 1.

[2] Griffin, S., Case, R., & Capodilupo, A. (1995). Teaching for understanding: The importance of the central conceptual structures in the elementary mathematics curriculum. In A. McKeough, J. Lupart, & A. Marini (Eds.), *Teaching for transfer: Fostering generalization in learning*. Mahwah, NJ: Erlbaum, p. 123.

[3] 21st century skills for 21st century jobs. (1999). Published by the U.S. Department of Commerce, U.S. Department of Education, U.S. Department of Labor, National Institute for Literacy, and Small Business Administration, Washington, DC and Gott, S.P., Hall, E.P., Pokorny, R.A., Dibble, E., & Glaser, R. (1993). A naturalistic study of transfer: Adaptive expertise in technical domains. In D.K. Detterman & R.J. Sternberg (Eds.), *Transfer on trial: Intelligence, cognition, and instruction*, Norwood, NJ: Ablex.

[4] The cognitive skills required to pass the GED are based on Bloom, B., et al. (1956). *Taxonomy of educational objectives.* New York: Longmans Green, used by most high schools and textbook publishers to design curricula. Bloom's opinion was that application (his term for transfer) was more difficult than rote knowledge and simple comprehension (lower-order thinking), but prerequisite to evaluation or synthesis (higher-order thinking).

[5] Swartz, R. (1988). *Official teacher's guide to the GED.* Washington, DC: ACE, p. 94.

[6] For overviews of the failure to find transfer in the research, see The study of transfer, Chapter 1 in Singley, M.K., & Anderson, J.R. (1989). *The transfer of cognitive skill.* Cambridge, MA: Harvard University Press. For arguments against transfer, see Lave, J. (1988). *Cognition in practice.* Cambridge, England: Cambridge University Press, and Detterman, D.K. (1993). The case for the prosecution: Transfer as an epiphenomenon. In Detterman & Sternberg, *Transfer on trial.* For examples of successful transfer, see Detterman & Sternberg, *Transfer on trial* and A. McKeough, J. Lupart, & A. Marini (Eds.). (1995). *Teaching for transfer: Fostering generalization in learning.* Mahwah, NJ: Erlbaum.

[7] Gick, M.L., & Holyoak, K.J. (1983). Schema induction and analogical transfer. *Cognitive Psychology, 15*, 1-38.

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[8] Lave, J., Murtaugh, M., & de la Rocha, O. (1984). The dialectic of arithmetic in grocery shopping. In B. Rogoff & J. Lave (Eds.), *Everyday cognition: Its development in social context.* Cambridge, MA: Harvard University Press, p. 82.

[9] Mayer, R.E., & Wittrock, M.C. (1996). Problem–solving transfer. In D.C. Berliner & R.C. Calfee (Eds.), *Handbook of educational psychology.* New York: Macmillan, p. 48.

[10] Bassok, M., & Holyoak, K.J. (1993). Pragmatic knowledge and conceptual structure: Determinants of transfer between quantitative domains. In D.K. Detterman & R.J. Sternberg (Eds.), *Transfer on trial: Intelligence, cognition, and instruction*, Norwood, NJ: Ablex, p. 48.

[11] Perkins and Salomon argue that there is "low road" transfer, where new information automatically triggers routines, and "high road" transfer, which requires, "Mindful abstraction . . . from one context for application in another." Perkins, D.N., & Salomon, G. (1988). Teaching for transfer. *Educational Leadership, 46* (1), 22-32, p. 25. Reed, S.K., Dempster, A., & Ettinger, M. (1985). Usefulness of analogous solutions for solving algebra word problems. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11* (1), 106-125.

[12] Frederiksen, J.R., & White, B.Y. (1988). Intelligent testing within an intelligent tutoring system. *Machine-Mediated Learning, 2*, 351-372, p. 366.

[13] Schraw, G. (1998). On the development of adult metacognition. In M. C. Smith & T. Pourchot (Eds.), *Adult learning and development: Perspectives from educational psychology.* Mahwah, NJ: Erlbaum, p. 96.

[14] Robbie Case argues that there are knowledge structures he calls "central conceptual structures" (like the number line) that cross domains. McKeough, A. (1995). Teaching narrative knowledge for transfer in the early school years. In A. McKeough, J. Lupart & A. Marini (Eds.), *Teaching for transfer: Fostering generalization in learning.* Mahwah, NJ: Erlbaum.

[15] Brown, A.L., Bransford, J.D., Ferrara, R.A., & Campione, J.C. (1983). Learning, remembering, and understanding. In J.H. Flavell & E.M. Markman (Eds.), *Handbook of child psychology: Vol. III. Cognitive development* (pp. 106-126). New York: John Wiley & Sons, p. 146. Learning disabled: Lupart, J.L. (1995). Exceptional learners and teaching for transfer. In A. McKeough, J. Lupart, & A. Marini (Eds.), *Teaching for transfer: Fostering generalization in learning.* Mahwah, NJ: Erlbaum. Some researchers feel that transfer never happens, see Detterman, D.K. (1993). The case for the prosecution: Transfer as an epiphenomenon. In D.K. Detterman & R.J. Sternberg (Eds.), *Transfer on trial: Intelligence, cognition, and instruction*, Norwood, NJ: Ablex. Gott, et al. argue that students who can transfer have more elaborated mental models, in A naturalistic study of transfer.

[16] Byrnes, J.P. (1996). *Cognitive development and learning in instructional contexts.* Boston: Allyn and Bacon, p. 74-80.

[17] McKeough, Lupart & Marini, Teaching for transfer and Butterfield, E.C., & Nelson, G. (1991). Promoting positive transfer of different types. *Cognition and Instruction, 8* (1), 69-102, p. 71.

[18] Cormier, S.M., & Hagman, J.D. (1987). Introduction. In Cormier, S.M., & Hagman, J.D. (Eds.), *Transfer of learning: Contemporary research and applications.* San Diego: Academic Press, p. 3.

[19] Detterman, The case for the prosecution.

[20] Mayer & Wittrock point out that school problems usually have "one right answer" (are well-defined), but real-life problems often have many "right answers" (are ill-defined, such as a business letter, which could be written in many different ways), Problem–solving transfer, p. 48.

[21] Brown, J.S., Collins A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18* (1), 32-42.

[22] Mayer, R.E. (1988). Teaching for thinking: Research on the teachability of thinking skills. *The G. Stanley Hall Lecture Series, 9,* 139-164, p. 153.

[23] Catrambone, R., & Holyoak, K.J. (1990). Learning subgoals and methods for solving probability problems. *Memory and Cognition, 18* (6), 593-603, p. 599.

[24] Brown, Bransford, Ferrara & Campione, Learning, remembering, and understanding, p. 143-144.

[25] Cooper, G., & Sweller, J. (1987). Effects of schema acquisition and rule automation on mathematical problem-solving transfer. *Journal of Educational Psychology, 79* (4), 347-362.

[26] Mayer, R.E. Teaching for thinking, p. 159.

[27] Gagné, E.D., Yekovich, C.W., & Yekovich, F.R. (1993). *The cognitive psychology of school learning* (2nd ed.). New York: Harper Collins, p. 237 and Mayer & Wittrock, Problem–solving transfer, p. 50.

[28] Lateral Transfer. Chapter 3 in Singley & Anderson, *The transfer of cognitive skill.*

[29] Sternberg, R.J., & Frensch, P.K. (1993). Mechanisms of Transfer. In D.K. Detterman & R.J. Sternberg (Eds.), *Transfer on trial: Intelligence, cognition, and instruction*, Norwood, NJ: Ablex, p. 29.

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[30] Bereiter, C. (1995). A dispositional view of transfer. In A. McKeough, J. Lupart & A. Marini (Eds.), *Teaching for transfer: Fostering generalization in learning*. Mahwah, NJ: Erlbaum, p. 27.

[31] McKeown, M.G., & Beck, I.L. (1990). The assessment and characterization of young learners' knowledge of a topic in history. *American Educational Research Journal, 27*, 688-726.

[32] Bransford, J., Brown, A., & Cocking, R.R. (1999). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.

[33] One collection of studies from many areas is Chi, M.T.H., Glaser, R., & Farr, M. (Eds.). (1988). *The nature of expertise*. Hillsdale, NJ: Erlbaum.

[34] Druckman, D., & Bjork, R.A. (Eds.). (1991). *In the mind's eye: Enhancing human performance*. Washington, DC: National Academy Press, p. 37.

[35] Wittrock, M.C. (1990). Generative processes of comprehension. *Educational Psychologist, 24*, 345-376.

[36] Reed, S.K. (1993). A schema-based theory of transfer. In D.K. Detterman & R.J. Sternberg (Eds.), *Transfer on trial: Intelligence, cognition, and instruction*, Norwood, NJ: Ablex, p. 51. See Brown, A.L., & Kane, M.J. (1988). Preschool children can learn to transfer: Learning to learn and learning from example. *Cognitive Psychology, 20*, 493-523, for startlingly similar results with 4-year-old children.

[37] Reed, Dempster, & Ettinger, Usefulness of analogous solutions, p. 123.

[38] Note that I am not referring to the kind of analogy used on some standardized tests, such as human:arm::dog:paw.

[39] Holyoak & Thagard use this as an example of an ambiguous analogy, since Kuwait is also a dictatorship, unlike Czechoslovakia, and it is not clear which country that Germany invaded should be "mapped" onto Kuwait. Holyoak, K., & Thagard, P. (1995). *Mental leaps: Analogy in creative thought*. Cambridge, MA: MIT Press, p. 131.

[40] Holyoak & Thagard, *Mental leaps*, p. 116.

[41] Mayer, R.E. (1992). *Thinking, problem solving, cognition* (2nd ed.). New York: W.H. Freeman, p. 432.

[42] Frederiksen & White, in Intelligent testing, point out that the water model interferes with learning about electronic troubleshooting. For example, if current can either go through a light bulb or through another circuit without a light bulb, it will short-circuit the light bulb. Water, in the analogous case, would flow through both "circuits," p. 367.

[43] Gick & Holyoak, Schema induction.

[44] Ross, B.H. (1987). This is like that: The use of earlier problems and the separation of similarity effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13* (4), 629-639, p. 632.

[45] Rogoff, B., & Gardner, W. (1984). Adult guidance of cognitive development. In B. Rogoff & J. Lave (Eds.), *Everyday cognition: Its development in social context*. Cambridge, MA: Harvard University Press, p. 102.

[46] Cooper & Sweller, Effects of schema acquisition and rule automation.

[47] Zhu, X., & Simon, H.A. (1987). Learning mathematics from examples and by doing. *Cognition and Instruction, 4* (3), 137-166. Zhu and Simon feel that classes were successful because students had to take primary responsibility for learning. Worked examples may free up working memory, since means-end problem solving strategies create a very heavy working memory load. Sweller, J., van Merrienboer, J.J.G., & Paas, F.G.W.C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10* (3), 251-296, p. 273.

[48] Cooper & Sweller, Effects of schema acquisition and rule automation, p. 352.

[49] Brown, Collins & Duguid, Situated cognition and the culture of learning, p. 32.

[50] Perkins & Salomon, Teaching for transfer, p. 30.

[51] Singley, M.K. (1995). Promoting transfer through model tracing. In A. McKeough, J. Lupart & A. Marini (Eds.), *Teaching for transfer: Fostering generalization in learning*. Mahwah, NJ: Erlbaum.

[52] Druckman & Bjork, *In the mind's eye*, p. 40-43.

[53] Gagné, Yekovich & Yekovich, *The cognitive psychology of school learning*, p. 238.

[54] Schraw, On the development of adult metacognition, p. 120. Mothers do this all the time with children, see Rogoff, B., & Gardner, W. (1984). Adult guidance of cognitive development. In B. Rogoff & J. Lave (Eds.), *Everyday cognition: Its development in social context*. Cambridge, MA: Harvard University Press, p. 101.

[55] Sternberg & Frensch, Mechanisms of transfer, p. 35.

[56] Sternberg & Frensch, Mechanisms of transfer, p. 35.

[57] Butterfield & Nelson, Promoting positive transfer, p. 83.

[58] Perkins & Salomon, Teaching for transfer, p. 28.

[59] Perkins, D.N., & Salomon, G. (1989). Are cognitive skills context-bound? *Educational Researcher, 18* (1), 16-25.

[60] Halford, G. (1993). *Mental models*. Hillsdale, NJ: Erlbaum, p. 185.

[61] Halford, *Mental models*, p. 187.

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[62] Reed, S.K. (1993). A schema-based theory of transfer. In D.K. Detterman & R.J. Sternberg (Eds.), *Transfer on trial: Intelligence, cognition, and instruction*, Norwood, NJ: Ablex, p. 48.

[63] Holyoak & Thagard, *Mental leaps: Analogy in creative thought*, p. 8.

[64] Cheng, P.W., & Holyoak, K.J. (1985). Pragmatic reasoning schemas. *Cognitive Psychology, 17*, 391-416, p. 397.

[65] Butterfield & Nelson, Promoting positive transfer, p. 94.

[66] Zhu & Simon, Learning mathematics from examples.

[67] Singley & Anderson, *The transfer of cognitive skill*, p. 236.

[68] Reed, Dempster, & Ettinger, Usefulness of Analogous Solutions, p. 117 and Cooper & Sweller, Effects of Schema Acquisition, p. 349.

[69] Gagné, Yekovich & Yekovich, *The cognitive psychology of school learning*, p. 170-173.

[70] Salvucci, D.D., & Anderson, J.R. (1998). Analogy. In J.R. Anderson & C. Labierre (Eds.), *The atomic components of thought*. Mahwah, NJ: Erlbaum, p. 352.

[71] Catrambone & Holyoak, Learning subgoals and methods, p. 595.

[72] Druckman & Bjork, *In the mind's eye*, p. 45-47.

[73] Two reviews of more than 107 transfer studies found 7 studies that did show transfer—6 of the 7 asked students think out loud about how well their strategies worked.

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Fact Sheet 3: Mental Models

Principle: More and Better Models Help Learning

> "When I introduce a unit on 'magical realism,' I ask students if they have ever had something inexplicable happen to them. After students relate ghost stories and strange sightings, I tell them my ghost story and explain how these stories relate to the idea of magical realism."—Art teacher M. Peach Robidoux[1]

Questions for teacher reflection

- Take 15 seconds to write down everything you can think of that is in a kitchen.
- Take 15 seconds to write down everything you can think of that is on a golf course.

These are your mental models for 'kitchen' and 'golf course.'

- Which list was longer? Why? How much experience do you have with kitchens? With golf courses?
- Which list do you think your students would have the most difficulty with?
- If your students were reading a passage related to kitchens, do you think they would have more or less trouble than if they were reading a passage related to golf? Why?

What we know

What Is A Mental Model?

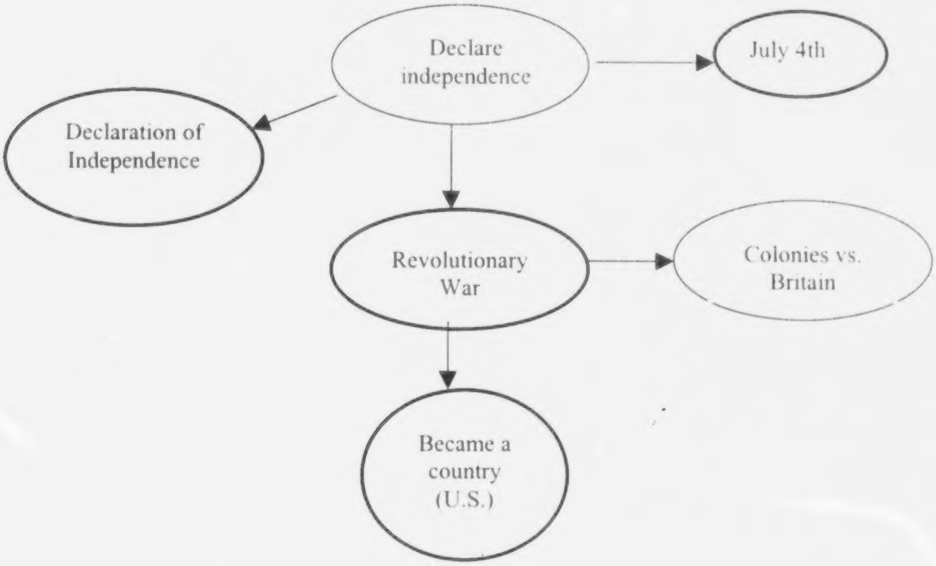
☞ Just like your "mental maps" of what is in a kitchen or golf course, everyone has many complex models of common things and events in the world.[2] We have thousands of mental models--for places like offices or schools, for actions like buying things or walking down the street, for objects like beans, for text, and even for learning. Mental models do not stay the same; we change and deepen our mental models as we gain experience in the world.[3] Mental models shape how we understand our experiences, and our experiences in turn shape our mental models.

☞ These mental models affect how we understand what we see and hear.[4] For example, people gave very different summaries of the exact same story when it had the title "Going Hunting" than when it had the title "An Escaped Convict."[5] Their "hunting model" and "escaped convict model" shaped how they understood the story. Likewise, people's mental models shape what they pay attention to when they read. In another study, musicians remembered musical details when they read a passage including, "Early in the evening Mike noticed Pat's hand and the many diamonds. As the night progressed the tempo of play increased." Non-musicians remembered details about the card game instead.[6].

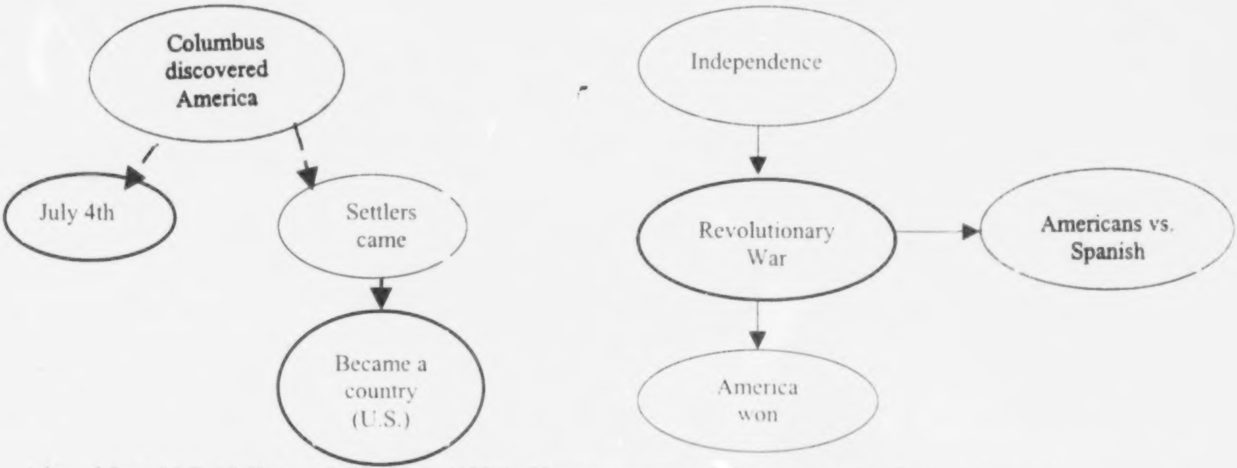
☞ A mental model is a kind of shorthand for experience (or a stereotype of it). The model includes what is **common** to all kitchens or golf courses, or whatever. A mental model is made up of what we do not have to pay attention to because we take it for granted.[7] We do not have to wonder, 'What is that big white box in the kitchen?' and we do not need to open it up and feel that it is cold inside because we know to expect a refrigerator.

☞ In a mental model, all of the parts are interconnected. In a "kitchen model," "kitchen" is probably linked to refrigerator, cabinets, sink, food, etc. "Food" is probably linked to refrigerator and cabinets. In another culture, the mental model might have an open fire instead of a stove. I suspect many of my students would put "people" in their list of what is in a kitchen, even though I did not.

An Ideal Mental Model for Parts of the American Revolution


Declare independence
July 4th
Declaration of Independence
Revolutionary War
Colonies vs. Britain
Became a country (U.S.)

Parts Of An Actual 6th Grade Student's Mental Model


Columbus discovered America
July 4th
Settlers came
Became a country (U.S.)
Independence
Revolutionary War
Americans vs. Spanish
America won

Adapted from M.G. McKeown & I.L. Beck. (1990). The assessment and characterization of young learners' knowledge of a topic in history. *American Educational Research Journal*, 27, 688-726.

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Terms in **bold** ovals were mentioned in the questions that children were asked.
Solid lines → represent true relationships.
Dashed lines - - → represent incorrect relationships.
Terms in **shaded** ovals are irrelevant information.[8]

☞People have remarkably similar models for common things and events. For example, 73% of people in one study agreed on six events that would always happen when eating at a restaurant (for example, looking at the menu, ordering food, etc.).[9] Mental models are also linked to each other. The "refrigerator" in your kitchen model is also part of your "electrical appliance" model, your "cold" model, and your "Sears" model.

How Do Mental Models Help Us Think?

☞Mental models help our thinking in five different ways:[10]

1. They make learning and memory more efficient because the information is *organized* (poodle, greyhound, and pit bull are stored with "dog," not stored separately as "poodle dog," "greyhound dog," etc.).
2. They set up expectations, including what to pay attention to (when you see a dog, you expect it may bark or bite).
3. They help us remember things associated with specific objects (when you think of "dog" you also think of fur, fleas, puppies, etc.).
4. They help us comprehend because they organize background knowledge (when we read *Lassie*, we think of dog characteristics—loyal, guards, good for children, etc.).
5. They include problem-solving shortcuts.[11]

Most stories that are interesting are actually about situations that do not fit our models. They are interesting because they are not the norm.[12]

☞Mental models can also interfere with thinking because they are stereotypes. When we remember something we read, our memories tend to capture the general sense of the reading, but not the precise details.[13] As time passes, our memories of a particular passage tend to look more like our stereotypes and less like the passage itself.[14]

Background Knowledge And Mental Models

☞People with little background knowledge of a topic will have a poor mental model for that topic. They have a hard time learning new information about the topic because they have no mental model to structure their thinking.[15] A mental model is a kind of summary of background knowledge about a topic.

☞Mental models may mirror the way information is stored in the mind in networks of associated facts. You may have noticed that the mental models above look like the idea maps or bubble diagrams used by many writing teachers. See Fact Sheet 8: Long-term Memory and Learning for more information.

☞Students with learning disabilities may not use their background knowledge as much as other students. They may benefit more from pre-reading discussions or pre-reading questions which activate what they already know about a topic before they read.[16]

Mental Models Are Organized

☞Mental models are not just collections of related facts, they are organized. Experts in fields, especially, have more specific information grouped under more general ideas. Novices' mental models tend to be jumbled, even when they have the same information as experts.[17] For example, I was teaching a class at a university. On the first day of the class, I figured out how to get from the apartment where I was staying to the classroom. I also figured out how to get from the apartment to the dining hall. But I had to look at a map to figure out how to get from the classroom to the dining hall. I had the information, but it was not well-organized.

☞Experts also have knowledge about when to use a mental model. For example, there is a difference between knowing how to add two fractions and knowing when to add two fractions. Knowing when to use information makes the link between "school learning" and "real life."

☞Students also have mental models about learning itself. For example, they may think that they will learn what they need to simply by coming to class and listening.

Expectations

☞Mental models set up readers' expectations before they read.[18] For example, if you read a romance, you expect a lonely heroine, a love object, an obstacle to love, and a happy ending. This mental model helps readers to understand because they do not have to pay attention to details that just fit their expectations.[19] Most stories have a common structure: a hero who faces some difficulty and then overcomes it. People who are asked to remember stories from other cultures tend to leave out certain details and add other details that make the stories take on this more familiar form.[20]

☞Mental models also bring ideas to mind when we read. When we read the word "car," "we assume that it has an engine, headlights, and all of the standard characteristics of an automobile."[21]

☞Many students find stories easier than textbooks. One reason is that they have a "story model" that tells them what to expect but no "textbook models."[22] For example, very few stories give a definition followed by supporting evidence, but many textbooks do. In fact, without a mental model, a textbook can seem like so many disconnected sentences.[23]

Comprehension

☞To understand what we read, we need to draw on all of our knowledge about the topic. Even a simple sentence such as "The truckdriver stirred the coffee in his cup." requires a "drinking model" in order to understand that the man must have had a spoon.[24] Children younger than fourth grade simply do not make these connections when they read [25] (that the man must have had a spoon). Studies show that good readers sometimes "remember" information that was not in a text because they added information from their own background knowledge. For example, a reader may think that the "coffee" sentence specifically mentioned a spoon. Good readers mistake their background knowledge for ideas in the text.[26]

Poor readers tend to underestimate how much they already use background knowledge when they read and how much more they need to.[27] They may assume that the meaning comes entirely from the text, and therefore fail to use what they know.

When students have trouble understanding, the mental models theory suggests four possible problems:[28]

1. The reader does not have a (good enough) mental model for the topic.
2. The reader has a model, but the text does not give the right clues to bring that mental model to mind.
3. The reader found a different meaning from the one the author intended (a different mental model).
4. The reading challenges the reader's model, and he or she may need to expand the model.[29]

Solving Problems

A lot of thinking involves solving problems, and problem solving uses mental models. Even reading includes problem-solving, such as inferring the meaning of a word the reader does not know. Common mental models that help with everyday problem solving include, "Which way am I allowed to drive on the street?" and "How should I talk to my supervisor?".

We may not have any trouble solving logic problems that take place in a familiar setting because we already have mental models for them. In one study, the problem "Which of these people is legally allowed to drink alcohol?" was easy to solve. But when problems are in an unfamiliar setting we do not have a mental problem-solving model for the situation.[30] In the same study, very few people were able to answer a question **with identical logic** that asked, "Which letter needs more Italian postage?" (although it was easier for Italians to answer than for Americans!).

Good problem-solvers have more and better-developed mental models than poor problem-solvers.[31] For example, there are four common types of arithmetic word problems, which are also reading comprehension problems. Good word problem-solvers can read a problem (often just the first few words)[32] and know how to solve it because they match it to a type of problem. A mental model for an addition problem might look like this.

> "Person 1 has a certain amount of things. Person 2 gives Person 1 a certain amount more. How many does Person 1 have now? Solution: Add the two amounts together."[33]

☞ Problem-solvers with few, incomplete, or wrong mental models for "school-type" problems may not know how to solve the problem, or they may approach it in a way that does not work. For example, inexperienced physics students in one study lumped all "pulley" word problems together even though some problems had to be solved using equations for tension on the rope and others using equations for gravity.[34] The mental models of experienced physics problem solvers included a lot of physics equations, but also information about when to apply them. The inexperienced students had a mental model for physics problems that did not work.

☞ Mental models are also at work when students try to figure out what a poem means, or why a character in a play said what he did, etc. For example, in a poem most language is not direct. A "poem model" or a "play model" can help students understand better because they know to expect indirect language.

Summary

1. Mental models are complex networks of information about a topic (an office, buying something, walking down the street) that change as we learn.
2. They affect how we understand what we read and hear.
3. People share similar models for common events.
4. Mental models help thinking: they are efficient and organized, create expectations, provide memory cues, and include problem-solving models.
5. Mental models are closely tied to background knowledge.
6. Experts' models are highly organized.
7. Many students have a model for stories (narratives), but not textbook writing (expository prose).
8. Mental models allow us to make inferences.
9. Good problem-solvers have mental models for many types of problems.

What it means for teachers

Choosing teaching materials

🔍 Reading passages for low-level readers should be on familiar subjects. Students will understand them better because they have mental models for them. They may also be more motivated.

🔍 You may need to teach more facts than you are used to so that students have "raw material" for their models. Just be sure to integrate the facts into a well-organized model.

🔍 Information that fits into an existing model is easier both to understand and to remember.[35]

🔍 Limit the number of different mental models that students have to use at one time. Begin with a simple model, then add on to it.

Mental models

Your own mental model of a subject is really your road map for what to teach. For example, the four-paragraph essay format is a mental model for how a certain kind of writing should be done.

If understanding depends on mental models, then students must actively engage in learning, since it is their models that lead to understanding, not the teachers'.

Mental models can make students resistant to what the teacher says. For example, students who think that heavy objects fall faster may simply not believe what the teacher says about gravity. Science teaching, especially, has to confront the models (or lack of models) that students bring to the subject.[36]

Low-level readers and students with little knowledge of the world will have fewer mental models. Their mental models for school subjects will probably also have less information and be more disorganized. In short, 'The less you know, the less you can understand.'[37] Teachers need to help students both expand and organize the mental models that relate to students' academic goals.

Demonstrating or **modeling** is one of the most powerful teaching tools. (Parents are constantly teaching by modeling.) You can demonstrate your own use of mental models in three ways:

- Show how you use everything you know about a topic to figure out something that is not stated. For example, after reading the passage, "She broke the bottle against the bow and the crowd cheered," show students how you inferred that this is a ship christening, that the bottle probably had champagne in it, etc., etc.
- Put mental models on the board before and after reading to show students how new information fits into an existing model.
- Put disorganized mental models on the board (anonymously) and restructure them.

ADULTS

Adult students have had a lot of time to build mental models that do not work well for them at school. They may be quite attached to their mental models, even if these models do not help them solve school problems well.

Because mental models are organized, they help students think clearly. A person with facts but no mental model, "a) would have trouble learning similarly arbitrary additional facts about [the topic], b) would be vulnerable to confusions when attempting to recall and use facts about [the topic], and c) would be relatively slow to retrieve even well-known facts."[38] You can help your students by organizing their mental models.

If students misunderstand something, try to understand what their frame of reference is. Many misunderstandings happen because of different mental models.

🔑 Students who grew up in other cultures (even in the U.S.) will have different mental models. You may need to explain some background (as in the christening example) in order for students to understand a passage, even if they already know all of the vocabulary.

🔑 Paragraph headings are very important in readings because they tell the reader which mental model to activate. Consider adding your own paragraph headings for lower-level readers when reading material does not already have them.

Problem solving

🔑 If you explain a rule, also explain **when** to use it.[39] Good problem-solving models (like the adding fractions rule) also include when to use the rule.

Prior knowledge

🔑 Readers need background knowledge to "read between the lines." If they do not have this background knowledge, they will read literally.[40] Background knowledge needs to be organized.[41]

🔑 Anything new you want your students to learn needs to be linked to the mental models they already have. This means three things:
1) Identify students' prior knowledge before you teach (whether it is reading, writing, or math).
2) Activate that prior knowledge before you teach any subject.
3) Show students the links between the new information and what they already know.
Teachers also need to link up new bits of information to each other—to teach whole mental models.

Lesson Ideas

Pre-Reading

✍ Always have a discussion before you read.

- Ask questions about the topic. Even if students can't know the answers, just thinking out the questions activates their background knowledge.
- Ask students to predict what the story is about—use the title, illustrations, captions, and other clues. If students know nothing about the topic, you need to give them some background information first, otherwise prediction can lead to lower comprehension (because students form preconceptions).[42]
- Ask students what they already know about the topic.[43]

✍ Review the mental model for a passage with students before they read about an unfamiliar topic.[44]

✍ For students who are new to textbooks (if they have mostly read stories), explain how the passage is organized. Does it explain a concept, give a list, use cause-and-effect, divide things into categories, or compare and contrast? These are five common types of text that may all be unfamiliar to your students.[45]

Reading Assignments

✍Help students see that they use their own background knowledge in reading. Mary Egan suggests giving students a pile of (mock) bank checks that "tell a story." For example, the first check is to an airline company. The second one is to a campground. The third is to a hospital. Students then have to figure out what happened, and in order to do that, they have to add all of their own background knowledge about vacations, hotels, hospitals, and so on.[46]

After Reading

✍Begin a lesson with a bubble diagram about the topic generated by the class.[47] At the end of the class, add on what they learned and reorganize the diagram (grouping items and concepts) if needed.

✍Choose a reading that requires a lot of inferences (something very American would be a good choice). Ask inference questions and ask students where they got the answer. It wasn't from the reading alone!

✍Ask each student to do a bubble diagram before and after learning about a topic as a way of testing what students have learned.[48] Ask students to look at their "before" and "after" models and write in their journals about the differences.

General

✍Do the "kitchen" and "golf course" exercises with students and ask them why they think they got the results they did.

✍Everyone has some well-developed models for familiar activities. Ask students to make a diagram for something they know how to do very well, and you do not know much about. (For my students, this might be "inner-city street survival.") Compare your models and have a discussion about why your models are different.

✍Present multiple examples of an object or situation and ask students to name what is common across these examples.[49] For example, dogs, cats, and hamsters are all mammals (they are also pets). Add horses, pigs, and cows, and they are all domesticated animals (as well as mammals).

NOTES

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[1] Slavin, R. (1997). *Educational psychology: Theory and practice* (5th ed.). Boston: Allyn and Bacon, p. 260.
[2] The terms "schema" (the plural is "schemata"), "scripts," and "frames" have all been used, with slightly different meanings. "Mental models" is also used by P. Johnson-Laird for solving deductive syllogisms and G. Halford for

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understanding. David Rumelhart has argued that schema are "the building blocks of cognition," "fundamental elements upon which all information processing depends," and "our private theory or the nature of reality." Rumelhart, D.E. (1980). Schemata: The building blocks of cognition. In R.J. Spiro, B.C. Bruce, & W.F. Brewer (Eds.), *Theoretical issues in reading comprehension,* (pp. 33-58). Hillsdale, NJ: Lawrence Erlbaum.

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[4] Bransford, J.D., & Johnson, M. (1973). Considerations of some problems of comprehension. In W.G. Chase (Ed.) *Visual Information Processing*, New York: Academic Press, p. 391 and Anderson, R.C., & Pearson, P.D. (1984). A schema-theoretic view of basic processes in reading comprehension. In P.D. Pearson (Ed.), *Handbook of reading research: Vol. I.* New York: Longman, p. 201.

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[11] The cognitive psychology term is *heuristics*.

[12] Schank & Abelson, Scripts, plans, goals, and understanding, p. 45.

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[21] Rumelhart, Schemata, p. 38 and Brown, A.L. Bransford, J.D. Ferrara, R.A., & Campione, J.C. (1983). Learning, remembering, and understanding. In J.H. Flavell & E.M. Markman (Eds.), *Handbook of child psychology: Vol. III Cognitive development,* pp. 126-129, 141. New York: John Wiley & Sons, pp. 99-100.

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[23] Rumelhart, Notes on a schema for stories, p. 226.

[24] Byrnes, *Cognitive development*, p. 115.

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[33] Byrnes, *Cognitive development,* p. 21.

[34] Chi, Feltovich, & Glaser, Categorization and representation of physics problems.

[35] Slavin, *Educational psychology,* p. 212.

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[49] Byrnes, *Cognitive development,* p. 24.

Fact Sheet 4: Thinking About Thinking

Principle: Teach Students to Notice Their Own Thinking

> "Leslie . . .has a problem in [her] approach to studying . . . [She] has attended class and completed reading assignments faithfully, copying down notes all the while. The results of her efforts are pages upon pages of information from the lectures and right answers, which she does not understand, copied from the textbook. Leslie does not need to study longer or harder, she needs to study smarter."—Patricia Cross, Teacher and Trainer[1]

Questions for teacher reflection

- Why are you reading this fact sheet?
- Do you think it will be easy or hard for you to understand?
- What do you already know about thinking about thinking?
- Read this passage:

> We each put our cards in a pile. We both turn over the top card in our pile. We look at the cards to see who has the special card. Then we turn over the next card in our pile to see who has the special card this time. In the end, the person with the most cards wins the game.

Was any information missing? How did you know?

- What do you do if you don't understand a paragraph you just read?

All of these questions got you to think about your own thinking.

What we know

What Is "Thinking About Thinking"?

☞ Good readers ask themselves a lot of questions before, during, and after reading.[2]

- What kind of writing is this?
- Why am I reading it (to study, for fun)?
- I don't think I understood that paragraph, should I re-read it or ask for help?

You probably are not even aware that you ask yourself these questions . . . until you read something that you have trouble understanding.[3]

☞ Some thinking about thinking is about being aware of your own thinking while you read,[4] such as:

- Am I good at learning this subject? Will I need to work harder to understand it?
- Do I understand this page?[5]
- What do I already know about this topic?
- Did the story match the predictions I made before I read?
- Can I answer the questions at the end of the chapter?

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- Have I studied my spelling words well enough for the quiz?

This kind of awareness develops gradually in children. Six year olds, for example, often think they have learned facts or that they understand, but they do not. They may think that directions are clear when they are not.[6]

☞ But being aware of your own thinking is not enough.[7] Readers also need to know when they do not understand. And they need to change their strategies, which they do not always know how to do.[8] Readers can:

- Re-read or read ahead to try to understand a passage.
- Study more by re-reading, repeating lists out loud, using flash cards, or other study methods.
- Make a diagram, chart, or drawing to help understand how information is related.
- Check their answers to make sure they are right.
- Ask a friend or teacher, use a dictionary, or get other help.

An early study found that while teachers asked a lot of reading comprehension questions they did not teach students how to answer the questions.[9] The advantage of teaching strategies is that students can become more independent learners and can continue to learn on their own after they leave school.[10] It is important to understand that these kind of strategies are just one tool, not the only way to improve comprehension.[11]

How Can Thinking About Thinking Help?

☞ Thinking about thinking can:

- Help *teachers* understand what thinking strategies students are using and
- Help *students* learn new thinking strategies and when to use them.[12]

Which Thinking Strategies Can Be Taught?

☞ Many studies have shown differences in thinking strategies between good readers and poor readers. More than 150 strategies have been identified.[13] Not all strategies used by good readers will help poor readers. For example, asking students to imagine a science description in their minds may not work for them, especially if they have poor background knowledge. Some strategies cannot be taught in the classroom. For example, the most effective way to build vocabulary is to read, a lot! But only a small amount of this reading can be done at school. So which reading strategies really work and can be taught?[14]

☞ Many thinking strategies in general require background knowledge.[15] For example, to read a social studies graph about population before and after the Civil War, students need to know that many people were killed during the war, how to read a graph, and so on (see Fact Sheet 1: Literature is not Science for more information). That said, there are three general reading strategies that are mentioned in many sources, show good results, and are based on a large number of studies. These strategies have also worked especially well for poor readers and students with learning disabilities.[16] The three strategies are:

1. Discuss what you already know about the topic.
2. Ask and answer questions as you read.
3. Summarize what you have read.

☞ These strategies work best when they are taught in a structured way using real reading materials.[17] They probably work because they get students to engage actively with reading and really think about and make sense of what they read.[18] Interestingly, good readers do not say that anyone taught them how to do these things, they just do them.[19] However, the research shows that teaching poor readers these strategies can help them improve their skills.

Discuss What You Already Know About The Topic

☞ This is covered in detail in Fact Sheet 3, Mental Models. Students can have a discussion about the topic or predict what will happen in a story. They can also make predictions based on what they know and by looking at illustrations, captions, paragraph headings, or other clues. Note: This strategy should not be used when students have no background knowledge or for history texts or disorganized textbooks, where the reader can not predict what will come next.[20]

Ask Questions While Reading

☞ Teaching students to make up questions about the main point of a paragraph is a remarkably powerful strategy for improving comprehension. These are usually short "Why," "Who," "What," "When," and "Where" questions. They should not relate to trivial details in the paragraph, like a "trick question" on a test, but get to the main idea. Questions will be harder to make for unfamiliar topics and easier for familiar ones. Students need to be explicitly taught how to make up good questions.

☞ Another way to teach the same skill is to ask students to extend sentences with the word "because." For example, if students need to learn that the seasons are caused by the tilt of the Earth's axis, they can complete the sentence, "The seasons are caused by the tilt of the Earth's axis because ____________________."

Summarize

☞ A good student answer to the student question should be a summary of the paragraph. Answers should come from the reading, not just from students' background knowledge. Summaries will be harder to make for unfamiliar topics and easier for familiar ones.

Other Strategies

☞ Another often-mentioned strategy is to notice what you understand and what you do not and find ways to figure out what you don't understand.[21] Students need to know a range of effective ways to study once they realize they do not know a subject well enough.[22] Figuring out why a fact is true is a powerful way to remember it. More studying will be needed for unfamiliar topics than for familiar ones. Fact Sheet 8: Long-Term Memory and Learning includes study strategies from a large number of studies that show good results.

☞ Other reading comprehension strategies that are commonly recommended but not as well proven include:

- setting reading goals (why? how long?)
- predicting what will happen
- taking notes
- finding the main idea
- forming a mental image
- thinking about author and audience
- using illustrations, graphs, and other graphics
- explaining how texts are put together
- making idea maps, diagrams, or charts
- self-checks during and after reading
- re-reading or reading ahead

Strategies That Are Not Effective Enough

☞ Several "sacred cows" of the teaching world have been shown to be ineffective. That is, students either do not learn from them, or learn much less than from the proven strategies above:

Background Knowledge

- Using analogies if learners do not know the original concept and limitations of the analogy are not explained.
- Forming mental images of abstract ideas or areas that students know nothing about.
- Activating prior knowledge about a topic when students do not have any.

Reading—Decoding

- Whole language reading instruction that uses no phonics at all when students do not know how to decode.
- Using only context clues to figure out an unknown word (students also need to know how to use the word itself—prefixes, suffixes, sounding out, etc.).

Reading Comprehension

- Asking comprehension questions without teaching students how to answer them.
- Explaining the relationships between a question and its possible answers.
- Explaining to normal readers how stories are put together.
- Teaching "good reader" strategies that are logical, but unproven, such as spending more time studying less precise passages.[23]
- Simply explaining how to do a strategy without making time for students to practice with some guidance and get feedback.[24]

Teaching Vocabulary

- Teaching vocabulary with dictionary definitions (more detailed plain-language definitions are needed).
- Teaching vocabulary by simply having students write new sentences.

Other

- Doing labs or discovery learning without preparing students for what they are looking for and why, or without giving feedback.

Summary

1. Good readers are very aware of their own thinking. They ask themselves whether they know anything about the topic before they read, whether they understood what they just read, and whether they are ready for a test. Poor readers do not have this kind of self-awareness of their own thinking.
2. These strategies do not develop on their own for most readers, they must be taught.
3. Talking out loud about your own thinking as you do a problem can really help students learn how to pay attention to their own thinking.
4. Three successful strategies that can be taught are: pre-reading discussion, generating questions during reading, and summarizing after reading.
5. Strategies take quite a while to teach, but they can be very powerful. Teaching strategies includes:
    - explaining why the strategy will be useful,
    - demonstrating the strategy,
    - giving students a chance to practice,
    - providing support during practice,
    - giving students feedback, and
    - discussing how the strategies helped.

What it means for teachers

Self-Awareness As A Learner

ADULTS

Adults have had a long time to decide whether certain topics are easy to learn or hard to learn. These ideas may be more entrenched in adult students than in children and harder to change.

Reflecting on learning can be most effective when a student is new at a school or in a class.[25] Discussing and writing about thinking, learning, and school may be good early assignments.

You can learn a lot about how students think and how many (or few) reading strategies they use by asking them to think aloud as they read.[26] You may want to do this one-on-one.

It may also help students if you point out when they use particular strategies. For example, after a student reads, ask, "Did you notice that you sounded out most of the words yourself this time? That is a good strategy. Next time, try making a list of words to look up."

Teaching Reading Strategies

Teach only one strategy at a time.[27] Each strategy takes many hours to teach—"good strategy instruction is very hard." In several schools, strategy teaching has made school more enjoyable for both students and teachers.[28]

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Strategies need to be taught slowly and with a lot of opportunity for students to practice. Students need to know what the skill is, but also why it is important and when to use it.[29] To teach strategies:

- Explain why using the strategy will improve learning.
- Demonstrate how and when to use the strategy.
- Have students practice using the strategy.
- Teachers need to support students while they learn the strategy by asking open-ended questions.
- Let students explain what they understood from their reading.
- Give them feedback on their answers.
- Debrief with them about how useful the strategy was to them.[30]

Here is an example from a literature lesson using summarizing:

1) **Explain why to use the strategy.**

   "Today we are going to learn about making a summary of a story. This will help you learn and remember better because you will put the story in your own words. To make a good summary, you have to really understand the story."

2) **Demonstrate how and when to use the strategy.**

   "You should use this strategy whenever you have to study a story for a test or when you need to work extra hard to understand something you read. You can use it in any topic. We will be using it on literature today, but you will also practice this in science class and social studies class with your teachers.[31] The only time a summary will not work is when you have to remember every little detail that you read, then you just have to memorize.
   I am going to explain how to make a summary and then I want you to practice it. Please follow along on the handout:

   - First, get rid of unimportant facts. The first scene of this play is on the first floor of an auto plant in Detroit in 1956. The most important thing is that it is in a factory.
   - Then find one word that says the same thing as a lot of examples. Mike, the character in the play, eats a sandwich, potato chips, soup, and a soda. 'Lunch' would be a good word that says the same thing.
     Mike also puts paint in the spray gun, turns on the fan, turns on the conveyer belt, and paints car doors. 'Works' would be a good word that says the same thing.
   - We also need to look for a topic sentence or make one up. Plays never have topic sentences, so when you read a play you always have to make one up. So our topic sentence is the same as our summary, 'Mike started work and ate his lunch.'"

3) **Have students practice the strategy.**

   "Now I want you to practice in your small groups on Scene 2 from this play. Please use your worksheets to get rid of unimportant facts, find one word to take the place of other words, and make up a topic sentence. I want each group to write their answers on a sheet of poster paper and we'll put them up."

4) **Support students while they learn the strategy.**
   "It seems like your group is stuck on step 2. Can you find any long lists of things in this scene?"

5) **Let students explain** what they understood from their reading and ask why they gave the answers they did[32] or explain why the **teacher** gave the answer he or she did.[33]
   "Now that everyone has their papers up, I want you to explain what you did."
   "Why did you choose the word 'lazy' for the character of Louie?"

6) **Give students feedback.**
   "I agree with you that Louie didn't do his work, but I don't think he was lazy, I think he did not have the tools he needed. Would you please revise your summary?"

7) **Debrief with students.** Strategy instruction is more effective if students are taught to monitor whether or not the strategy is working for them.[34]
   "How did writing a summary help you better understand what you read in Scene 2?"

🔑 If you teach strategies, it is very important to periodically assess students' ability to use them.[35] Otherwise, you may not know if your students are able to use them, or you may keep teaching the same strategy even if students have mastered it.

🔑 Teaching strategies takes time![36] Students may need to practice the strategy for up to 60 hours. The strategies here are not effective if they are rushed.

Lesson Ideas

✍Ask your students what they think "learning" means.[37]

✍Ask students to think out loud as they solve a problem, such as why a character took a certain action. Ask open-ended questions and give feedback on their thinking process.[38]

✍Choose one reading strategy to teach this semester and follow the steps outlined above to teach it. Have students practice the skill every time the class meets.

✍Ask students to write in their journals about what subjects they find hard and how their thinking that a subject is hard might affect their learning.

✍Ask students to write in their journals about what they do if they don't understand a paragraph they just read.

✍Before reading a passage, ask each student to contribute one trick, tool, or strategy for understanding a reading passage. You may want to start with an example, such as "I sound out a word I'm not sure of to see if maybe I've heard the word before." Collect these learning tips and turn them into a poster to put on the wall or a study sheet to hand out to students.

✍Demonstrate how hard it is to understand what you read if you cannot use any strategies—read a passage about an unfamiliar topic out loud really fast, then read one on a familiar topic using as many strategies as you can. Explain the strategies you are using as you go along, "I am thinking about what I know about this topic. . . I notice there is a paragraph heading. . . I had to re-read that sentence. . . I am going to stop and try to explain to myself what I just read to make sure I understood it."

NOTES

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[1] Cross, K.P & Steadman, M.H. (1996). *Classroom research: Implementing the scholarship of teaching.* San Francisco: Jossey-Bass, p. 57.

[2] Early work on this topic, called metacognition, was done by John H. Flavell. For a summary see Flavell, J.H. (1985.) *Cognitive development* (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall, pp. 103-110. I focus here on what Flavell calls metacognitive strategy knowledge and other researchers have called cognitive regulation, see Hacker, D. (1998). Definitions and empirical foundations. In D.J. Hacker, J. Dunlosky, & A.C. Graesser (Eds.), *Metacognition in educational theory and practice.* Mahwah, NJ: Lawrence Erlbaum.

[3] Baker, L., & Brown, A.L. (1984). Metacognitive skills and reading. In P.D. Pearson (Ed.), *Handbook of reading research: Vol. I.* New York: Longman, p. 356 and Brown, A.L., Bransford, J.D., Ferrara, R.A., & Campione, J.C. (1983). Learning, remembering, and understanding. In J.H. Flavell & E.M. Markman (Eds.), *Handbook of child psychology: Vol. III. Cognitive development* (pp. 106-126). New York: John Wiley & Sons, p. 106-126.

[4] Called cognitive or metacognitive monitoring, see Narens, L., Graf, A., & Nelson, T.O. (1996). Metacognitive aspects of implicit/explicit memory and Reder, L.M., & Schunn, C.D. (1996). Metacognition does not imply awareness: Strategy choice is governed by implicit learning and memory. Both in L.M. Reder (Ed.), *Implicit memory and metacognition.* Mahwah, NJ: Lawrence Erlbaum.

[5] Called comprehension monitoring.

[6] Flavell, *Cognitive development.*

[7] Cross & Steadman, *Classroom research.*

[8] Called cognitive or metacognitive control.

[9] Durkin, D. (1979). What classroom observations reveal about reading comprehension. *Reading Research Quarterly, 14*, 481-538, cited in Pressley, M., Woloshyn, V., & Associates. (1995). *Cognitive strategy instruction that really improves children's academic performance* (2nd ed.). Cambridge, MA: Brookline Books.

[10] Smith, R.M. (1990). The promise of learning to learn. In R.M. Smith (Ed.), *Learning to learn across the life span.* San Francisco: Jossey-Bass.

[11] Personal conversation with James Byrnes, November 18, 1998.

[12] Beyer, B.K. (1997). *Improving student thinking: A comprehensive approach.* Needham Heights, MA: Allyn & Bacon.

[13] Rosenshine, B., & Meister, C. (1994). Reciprocal teaching: A review of the research. *Review of Educational Research, 64* (4), 479-530. The area of thinking skills generally is covered in Fact Sheet 1: Literature is not Science in this book.

[14] Pressley, et al., *Cognitive strategy instruction.*

[15] Candy, P.C. (1990). How people learn to learn. In R.M. Smith (Ed.), *Learning to learn across the life span.* San Francisco: Jossey-Bass.

[16] Pressley, et al., *Cognitive strategy instruction.*

[17] Pressley, et al., *Cognitive strategy instruction.*

[18] This is suggested by Candy, How people learn to learn; Pressley et al., *Cognitive strategy instruction;* Davidson, J.E., & Sternberg, R. J. (1998). Smart problem solving: How metacognition helps. In D.J. Hacker, J. Dunlosky, & A.C. Graesser (Eds.), *Metacognition in educational theory and practice.* Mahwah, NJ: Lawrence Erlbaum, and Byrnes, personal conversation.

[19] Baker & Brown, Metacognitive skills.

[20] Otero, J. (1998). Influence of knowledge activation and context on comprehension monitoring of science texts. In D.J. Hacker, J. Dunlosky, & A.C. Graesser (Eds.), *Metacognition in educational theory and practice.* Mahwah, NJ: Lawrence Erlbaum and Rosenshine & Meister, Reciprocal teaching.

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[21] One popular thinking skills program is Reciprocal Teaching, developed by Annemarie Palincsar and Ann Brown. Palincsar, A.S., & Brown, A.L, (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction, 2,* 117-175. Reciprocal Teaching is a) an integrated cognitive skills program that teaches Questioning, Summarizing, Predicting, and Clarifying using b) real reading materials in c) small student groups that are d) supported by an adult teacher, where students take turns assuming the role or teacher.

[22] Alan Knox disagrees with study skills programs and said at one conference that they are like "trying to help people learn to breathe during a nuclear winter," quoted in Candy, How people learn to learn.

[23] Good reader strategies may not be teachable because they operate beyond conscious control, Reder & Schunn, Metacognition does not imply awareness.

[24] Bransford, J.D., Stein, B.S., Shelton, T.S., & Owings, R.A. (1981). Cognition and adaptation: The importance of learning to learn. In J. Harvey (Ed.), *Cognition, social behavior, and the environment.* Hillsdale, NJ: Erlbaum, p. 102.

[25] Smith, The promise of learning to learn.

[26] Beyer, *Improving student thinking.*

[27] Pressley, et al., *Cognitive strategy instruction.*

[28] Pressley, M., El-Dinary, P.B., Brown, R., Schuder, T., Bergman, J.L., York, M., & Gaskins, I.W. (1995). A transactional strategies instruction Christmas carol. In A. McKeough, J. Lupart, & A. Marini (Eds.), *Teaching for transfer: Fostering generalization in learning.* Mahwah, NJ: Erlbaum, p. 183.

[29] Smith, R.M. (1990). Disseminating current knowledge about learning to learn. In R.M. Smith (Ed.), *Learning to learn across the life span.* San Francisco: Jossey-Bass.

[30] Pressley, et al., *Cognitive strategy instruction* and Rosenshine & Meister, Reciprocal teaching.

[31] Pressley, et al., A transactional strategies instruction Christmas carol, p. 189.

[32] Dominowski, R.L. (1998). Verbalization and problem solving. In D.J. Hacker, J. Dunlosky & A.C. Graesser (Eds.), *Metacognition in educational theory and practice.* Mahwah, NJ: Lawrence Erlbaum.

[33] Siegler, R.S. (1996). *Emerging minds: The process of change in children's thinking.* New York: Oxford University Press, p.201.

[34] Hacker, Definitions and empirical foundations.

[35] Nickerson, R.S. (1994). The teaching of thinking and problem solving. In R.J. Sternberg (Ed.), *Thinking and problem solving.* San Diego, Academic Press.

[36] Pressley, et al., *Cognitive strategy instruction.*

[37] Saljo in Candy, How people learn to learn.

[38] Lev Vygotsky argues that talking out loud and doing are connected in children, and that children learn to think by incorporating what they hear from adults. If this is true, then giving students feedback while they think out loud may be a very powerful tool to develop their thinking. Vygotsky, L.S. (1978). *Mind in society.* Cambridge, MA: Harvard University Press.

Fact Sheet 5: Getting Information into Memory

Principle: Students, Teachers, and Lessons Interact

> "I was teaching a reading class for ESL students, and I read an article about teaching reading for decoding, teaching for knowing words, and teaching for understanding. So I sat down with four students one at a time to figure out what they thought they were doing when they read. Only one of them was reading for understanding. And that totally changed the way I taught reading."—ESL Teacher

Questions for teacher reflection

☛ Read the first set of sentences on page 58 and turn back to this page. Without looking back at the sentences, fill in the blanks below:

The ____________ man bought the broom. The ____________ man read the sign.
The ____________ man gave money to the robber. The ____________ man bought the crackers.
The ____________ man found the scissors.[1]

☛ Read the second set of sentences on on page 58 and turn back to this page. Without looking back at the sentences, fill in the blanks below:

The old man hobbled across the room and picked up the valuable ______________.
She cooked the ____________.
The great bird swooped down and carried off the struggling ______________.
The ripe _____________ tasted delicious.
She dropped her ____________.[2]

☛ Were some of the words easier to fill in? Why do you think?

These questions got you to think about the connection between *understanding* and *memory*.

What we know

Students Need To Learn For Meaning

✍ Many teachers wish that students would try to understand what they are learning, not just memorize facts. Research shows that learning for understanding actually helps people remember better because it helps information get into memory in a way that is easier to recall:

- students who read for understanding have better comprehension and better grades;
- experts read for understanding more than beginners do and remember more of what they read;
- in laboratory studies, people who are asked to read single words and notice their meaning remember more than those who are asked to notice whether the words rhyme.

These studies show that doing more thinking, more detailed thinking, and more meaningful thinking puts more information into memory.

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☞ One of the most powerful tools for getting information into memory is to link new information to what you already know. This is covered in a separate Fact Sheet 8: Long-Term Memory and Learning.

Students Should Not Set "Get Answer" Goals

☞ More information goes into memory when students believe the point of reading is to understand (not just to answer the questions right). When students make understanding part of their own goals, rather than just being told by a teacher to do this, they do even better:

- Good readers tend to say that their goal for reading is to learn, while poor readers say their goal is to get through the passage.
- College students get better grades in the subjects where they read for understanding.[3]
- Students who believe that the point of school is to learn (not just to pass or to get good grades) also tend to learn more.[4]

ADULTS
Low-level adult readers and poor child readers both say that the point of reading is to "read the words well off the page." In other words, they do not see the point of reading as learning something or understanding it, but just saying the words. Most reading specialists agree that beginning reading should mostly, but not entirely, focus on decoding words. Once decoding is quick, most reading needs to focus more on meaning.

Experts Have Better Memory Because They Learn For Understanding

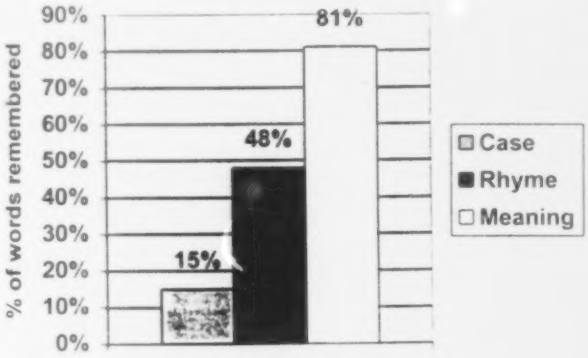
☞ Experts get more information into memory because they approach problems with a goal of understanding, not just getting the right answer.[5] Experts are better than beginners at knowing what they need to notice when they learn or study.[6] They know what kinds of questions will get them important information and what is irrelevant. For example, an expert baker knows that it is important to ask how old a container of baking powder is, but it does not matter whether it is an ammonium baking powder or not. Beginners are at a disadvantage because they do not know how to separate unimportant details from important ones.[7]

Teachers Need To Teach For Understanding

☞ Teaching for understanding helps students remember more.[8] In one study, students who were asked to focus on understanding remembered 39% more words than students who were asked to focus on getting the right answer.[9]

☞ More information goes into memory when people are simply asked to pay attention to what a word means (instead of

Learning for Meaning Improves Memory



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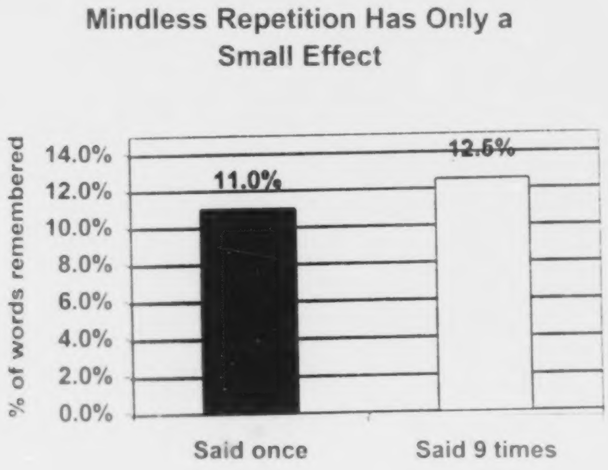
just sounding it out). In one study, people were asked "Is the word in uppercase letters?" or "Does the word rhyme with 'grog'?" or "Does this hop?" and then saw "FROG."[10] People who were asked to pay attention to meaning recognized 81% of the words later; for rhymes, 48%; and uppercase, 15%. Recognizing words is easier than repeating the whole list (just as a multiple-choice test is easier than a short-answer test). When people are asked to repeat back the list, meaning is still the best: 28% for meaning, 11% for rhyme, and 10% for uppercase.[11]

☞ In another study, people who were asked to notice whether a word was "pleasant" remembered more than twice as many words as people who just had to notice whether the letter "e" was in the word or those who had to estimate the number of letters in the word.[12] In another study, people who both rated how pleasant a word was and put the same words into categories remembered more than people who just did one of those.[13] In other words, the kind of learning that people are asked to do affects what aspects of a situation go into memory.[14] Comprehension questions are just one way to encourage students to do "deep processing."[15]

☞ Students can answer factual questions surprisingly well even if they do not understand what they have read. A pre-GED class at a center where I worked had read a gripping story about a mine cave-in and correctly answered comprehension questions, such as, "How many people were trapped in the mine?" and "How long were they trapped?" At the end of the class, one young man raised his hand and asked, "What were all these underage people doing underground?" The entire class thought they were reading about minors, not miners. The teacher had unintentionally structured the class so that the students did not have to read for understanding. Needless to say, she started asking more "Why?" questions and doing more pre-reading discussion to make sure the students had enough background to make sense out of what they were reading.

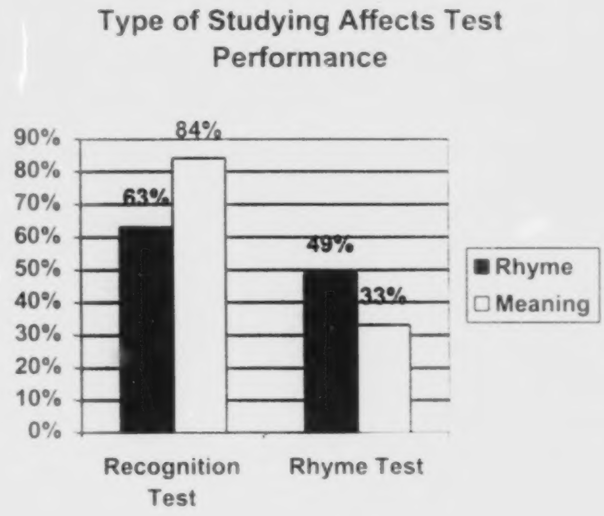
ADULTS
Most adults who we work with probably went to schools that emphasized fact memorization, not learning for understanding. Not surprisingly, students will have ideas about what learning is and what school is that can interfere with learning for understanding.



Teachers Need To Use Meaningful Repetition

☞ If "deep processing" does help memory, then less information should go into memory when people are not asked to read for meaning. When students re-read information over and over again, it may not actually help them learn much. In one study, students who spent extra time studying a passage did not learn it better unless they knew what the main point was.[16] In another study, people who said words once remembered 11% of them. Those who repeated the words 9 times only remembered 12.5% of them.[17] This is not just because repetition is boring. When people were paid to learn (which should be highly motivating!), meaningful learning was still almost twice as effective as meaningless learning.[18] Think for a moment about what is on the front and back of a penny. Which way does Lincoln's profile face? You have probably seen tens of thousands of pennies, but if you are like most adults, you will only be able to accurately remember three of the eight features on both sides of the coin (two images, five slogans and one date), because you have never had a reason to remember it.[19] Repetition is vital for learning, but **meaningless** repetition does not help learning much.[20] This may explain why flashcards are not that helpful for many students, unless the student associates the information with something that he or she already knows. Repetition needs to be made more meaningful before it will help learning.

Questions That Ask For Understanding Help Memory



☞ The type of test a student takes can affect what he or she remembers. If the test focuses on the meaning of a passage, students should study for meaning. If the test focuses on rhymes, they should study for rhymes. In one study, people were asked to pay attention to either rhymes or the meaning of a word when they saw it. For example, they were shown "________ rhymes with legal" and then saw either "EAGLE" or "TRAIN." People who got a meaning test did better on words they learned for meaning. They recognized 84% of the words where they paid attention to meaning and 63% of the words where they paid attention to rhymes. People who got a rhyme test did better on words they learned for rhyming. They recognized 49% of the words where they paid attention to rhyme and 33% of the words where they paid attention to meaning.[21]

☞ A question that is connected to the answer in a meaningful way is easier to answer than one that is randomly related, even if the random information is true. "What is something heavy?" was a better question to help people remember "piano" after reading the sentence, "The man lifted the piano." "What is something with a nice sound?" was a worse question (1/3 the number of correct answers).[22]

Keys to Memory: Into Storage And Out Of Storage

☞ Why do learning for understanding and the type of test affect what goes into memory? Memory includes putting information into storage and also finding the information later when it is needed.[23] These two actions, putting into storage and getting from storage, act together to affect learning.[24] In one study, people were given a word and asked to a) think of other words

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that "sound like" it, b) say whatever words came to mind, or c) think of words that have similar meaning. Each group made certain kinds of mistakes when they tried to remember the words. People who did the "sound-alike" task made "sound-alike" mistakes.[25] Similarly, information that is put into memory through rhyme is easier to remember as a rhyme. For example, if you have ever learned a famous poem that has been set to music, you may find that the only way you can remember the words is to sing it to yourself. The way information was put into storage (sound-alike) affected the way it was taken out of storage. One theory is that people use their memory of the learning experience to remember what they learned[26] (for example: "I remember it was a sunny day and the teacher was wearing a red shirt . . .").

Use Many Senses To Learn

☞ Information gets into memory better when it comes in through many senses instead of just one sense.[27] For example, a word that is heard, seen, spelled, and acted out in charades is easier to remember than a word that is just heard.[28] This may be because the word enters your memory through many paths, so there are more ways to find the word later when you are trying to remember it. For example, words that people can easily form mental images of (like "banana") are easier to remember than words that are hard to form images of (like "whereas").[29] Words that enter memory through many paths have more "hooks" for memory to grab onto.[30]

☞ So one explanation for the rhyming/meaning studies above is that all words are heard, but some are both heard and understood. The words that enter memory through both hearing and understanding can be remembered in more ways. Studies on vocabulary teaching show this: vocabulary classes where students do one type of exercise (like just making up new sentences) are not very effective. But classes where students do a wide variety of exercises (reading words in context and fill-in-the-blank exercises and matching exercises and making up sentences, and so on) are much more effective.[31] This also may explain why memory aids like making up a cartoon to remember the word or making a connection to a word you already know helps people to remember. These methods use more paths to get the word into memory, so there are more ways to get the information out when it is needed.

Learn By Doing

☞ Many teachers have a feeling that people learn better by doing, but what evidence is there? Five experiments where people heard words, watched an experimenter do something, or did something themselves, showed that "doing" has a powerful effect on learning. Those who "did" remembered from 1/3 to 2 times more than those who just heard, and they remembered for longer.[32] In another study, those who "did" remembered 31% more than those who just heard. However, visualizing was even better than doing for memory.[33] Doing creates an additional path into memory.

☞ Field trips can also increase student learning right after the field trip and later, **if students are actively involved**. One study compared high school geography students who:
1. took a field trip and had to do exercises and take notes, or
2. took a field trip where teachers pointed things out and students checked items on list, or

3. had no field trip.
The actively involved group scored 13% better than the passive group on a test after the field trip and 75% better on a test 3 months later.[34]

More Detailed Information Is Easier To Remember

☞ More information goes into memory from a detailed sentence than a simple one, because there is more to make it stand out in memory.[35] For example, the word "watch" in a detailed sentence like "The old man hobbled across the room and picked up the valuable watch off the mahogany table," was easier to remember than in a simple sentence like "He dropped the watch," (one-half as many right answers).[36] In another study, people who read main idea sentences followed by several supporting sentences remembered four times more main ideas as people who just read the main ideas alone, with no supporting details.[37] However, interesting but irrelevant information (like the family life of a military hero) gets in the way of students' remembering important ideas.[38] This may explain why people like color-coded stickers and files as a way to remember where information is, because the colors make your memory of the file more distinctive.

☞ The importance of including details may go against our teaching instincts, since we do not want to overwhelm students with unnecessary facts. But it seems that a certain level of detail is necessary to make the reading passage stand out in memory enough that it can be found later.

More Meaningful Information Is Easier to Remember

☞ More information goes into memory from sentences that are very meaningful, even if they are short. As you saw in the "Questions for Thought" above, short sentences can be very hard to remember. "The short man bought the stool," is easier to remember than, "The short man bought the broom." It makes sense that a short man would buy a stool, since he would need it to reach things. The more related the ideas are, the better people remember.[39] This may explain why people used the old form of phone numbers--such as ANderson 5-1212--which makes the number 26 (AN) easier to remember by associating them with a word (ANderson). Advertisers also take advantage of this when they turn phone numbers into words--555-READ is easier to remember than 555-7323. Likewise, you may turn the letters on your car's license plate into a word to remember them: BRK 275 becomes "break," and perhaps something significant happened to you in February, 1975, which helps you remember the numbers too.

☞ Good readers know that meaningful sentences are easier to remember than vague sentences or ones with random details. For example, "The hungry man got in the car to go to the restaurant" is easier to remember than "The hungry man got in the car to go for a drive."[40] Good readers also actively try to understand why information may be important.[41]

Summary

1. Students need to learn for meaning.
2. Students should not set "get answer" goals, they should set understanding goals.

3. Teachers need to teach for understanding.
4. Teachers need to use meaningful repetition.
5. Questions that ask for understanding help memory more than questions that ask for repetition.
6. People remember better when they use many senses to learn.
7. People remember better when they learn by doing.
8. More detailed information is easier to remember.
9. More meaningfully related information is easier to remember.

What it means for teachers

Students' Goals

- Help students set short-term goals for every assignment they do. "Why are you doing this?" It may help to give them lists of possible goals so they understand what a short-term goal is: "To understand what the writer is saying," "to learn more about plants," "to learn three new vocabulary words," "to get faster at solving problems," and so on. Tell students what your short-term goals are for every assignment you give.

- Give assignments where memorizing facts is not enough and have a discussion about what learning is. Is the point of school to "get facts"? Is it to pass the test? What does it take to pass?

- Reward students who show that they want to learn for understanding. Reward students for being on the right track, even if they do not have a full answer . . .yet. Stress that mistakes are part of learning, not shameful.

Teach For Understanding

- Ask more questions that require deep thinking and understanding and fewer factual questions. If student answers show that they do not understand the factual material, review it, but start by asking students to think.

- Teach students to think up explanations for why something is so. For example, to remember, "Cats like to lie in the sun," think of why that would be true, ". . . because it keeps them warm."[42]

- Relate the parts of every lesson to the "big picture" of the subject. For a lesson on how animals are adapted to their environments, tie adaptation back into the big picture of evolution.

- Ask students to justify their answers, even (or especially!) if they are right. Focus on the process of thinking and solving a problem more than the product.

- Consider teaching in more depth and covering less material. Students may actually learn better from a 10-week unit on the circulatory and respiratory systems than from 10 weeks on the human body.

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- Use rich reading materials that allow students to learn in some detail (see below).

- Make repetition more meaningful. Connect basic skills like spelling or memorizing multiplication tables with student goals—learn spelling so you can write to your grandmother, learn multiplication so you can run your own business.

- Make repetition more fun—play team or individual games, use computers for drill, use as wide a variety of exercises as possible.

- Get students to focus more on details when they read stories and focus on the relationships among major parts when they read textbooks.[43]

Questions For Understanding

- Be sure that the questions you ask are meaningfully connected to the content, not just surface details.

- Think about how students will need to remember what they are learning--will they have to recognize facts, recall a list, compare and contrast? Their learning strategy should match how they will have to remember the information.[44]

- If your tests are multiple-choice, make sure you spend some practice time doing multiple-choice questions during every class.

- Give assignments that make students work with what they have learned beyond repeating what the text says.[45]

Many Senses Are Better Than One

- Try to engage all of students' senses when you teach a topic. (See lesson ideas below.)

- Choose topics that can be taught with a hands-on component. Consider building scale models, measuring objects, paper cut-outs, role plays or skits, simple experiments, making graphs (instead of just reading them), or baking, sewing or building projects (for teaching math).

- Ask students to read, write, listen, and speak about every topic, not just read and answer fill-in-the-blank or multiple choice questions.

Doing Is Better Than Seeing Or Hearing

- Use props, do hands-on projects, and take field trips whenever possible. Students should be actively involved in seeing, doing, measuring, taking, notes, and so on.[46] Involve students in planning and researching the field trip.

- Make sure that your props, hands-on projects, and field trips are related to your class material! Too many field trips are not related to lessons; they are just "a day away from the classroom."

More Detailed Information Is Easier To Remember

🔑 Consider enriching GED textbook materials with a newspaper article, a few pages from a book on the topic, a high school textbook, or information from the Internet.

🔑 Liven up boring reading passages by adding new vocabulary words. (See the lesson ideas below.)

More Meaningful Information Is Easier To Remember

🔑 Unfortunately, many GED textbooks skip over WHY things are the way they are. For example, a biology text may say that arteries are stretchy (elastic) without explaining why they are so. (They need to be able to take more pressure from the heart beating than veins or capillaries do.)[47] You may need to add "Why" questions to your textbook readings to help make reading more meaningful.

🔑 Many GED textbooks are thin on details—they aim for short passages that students can get through quickly, perhaps in the hope that they will not get bored. Students may actually need more detail in order to remember.

🔑 Many GED textbooks also fail to explain how information is related. For example, they may say that the American colonies wanted to be represented in Parliament without explaining that they were not represented because they were a colony or explaining what a colony is.[48] You may need to identify where these explanations are missing and add them yourself.

Lesson Ideas

Student Goals

✍ Relate student goal-setting to a content lesson. For example, to use a map to plan a road trip (a social studies topic), you need to know where you are going!

Learning For Understanding

✍ Before reading, ask students why this information might be important.

✍ After reading about a topic, ask students to answer the "reporter's questions:" who? what? when? where? why? and how? (See What it means for teachers above.)

✍ Ask students to make up questions about the reading that relate to the main point of each paragraph (not details). Compile the questions and have the whole class answer them. See Fact Sheet 4: Thinking About Thinking for ways to teach new strategies.

Making Memorizing More Meaningful

✍ Teach vocabulary lessons from reading passages, not from a vocabulary book. Newspaper reviews of movies, plays, and concerts tend to use a large vocabulary, and some of them are very short.

✍ Have a spelling bee to encourage students to learn new spelling words or rules. Allow students to write down the word to check their spelling (since this is a more real-life task).

More Detailed Information is Easier to Remember

✍ Try a word substitution exercise: "Plants that receive enough sunlight grow more leaves" can become "Flora that receive sufficient illumination sprout lush foliage."

Hands-On Learning

✍ To teach about biology of plants, use fruits, root vegetables, and flowers. Look at the plants, feel them, smell them, taste them. Have students dissect a flower, plant, and vegetable (do not just do a demonstration in front of the room). Sprout seeds and watch them grow. Connect the way the plants look, smell, and taste with their functions (Do bitter plants keep bugs away? Do colorful flowers attract bees?).

✍ Have a field trip before you learn about a topic. Go to a relevant museum, watch a video or movie, visit a factory or other business or a historic site. Students may need a short briefing beforehand, but they are likely to be more interested in the reading after the field trip.

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Sentences for "Questions for Teacher Reflection"

First Set

The fat man read the sign.

The brave man gave money to the robber.

The short man bought the broom.

The thin man found the scissors.

The tall man bought the crackers.

Second Set

She cooked the fruit.

The ripe pear tasted delicious.

She dropped her pen.

The old man hobbled across the room and picked up the valuable watch.

The great bird swooped down and carried off the struggling mouse.

Fact Sheet 6: Memory and Learning

Principle: Memory is Vital for Learning

> A patient who has a brain injury from surgery for epilepsy cannot remember anything that has happened to him since the surgery. He cannot remember people who visit him, events in the news, or even the death of family members. He cannot remember anything good he has done or anything bad, so he does not know if he should be proud or ashamed of himself, if he is smart or dumb. "Without memory, there is no self."—Alan Baddeley, memory researcher.[1]

Questions for teacher reflection

- When have you had the experience of students learning a lesson in one class and forgetting it by the next class?
- What is your model for how memory works? Do you think it is like a computer? A filing cabinet?
- Why do you think some people have good memories and others do not?
- What do you think is the connection between memory and learning?

What we know

Memory And Learning

☞ What does memory have to do with learning? In order to learn new facts, interpretations, or skills, people must be able to remember them. Of course, we do not remember every fact that is presented to us. For example, you may not remember specific battles of the Revolutionary War, although you may remember the Boston tea party and at least one cause of it. But you probably remember just enough facts about the Revolutionary War that you could summarize it for an immigrant student who is not familiar with American history. A student with no memory would not be able to remember anything from previous lessons and would not be able to learn.

☞ Memory is not the same as learning. Memory is necessary for learning, but not sufficient.

☞ Memory is also very important in social interactions—remembering the name of a person we met at a party, a new neighbor, or family member; who reports to whom at work; appointments or obligations. Memory is also related to your sense of your self. Improving memory may help students outside of class, too.

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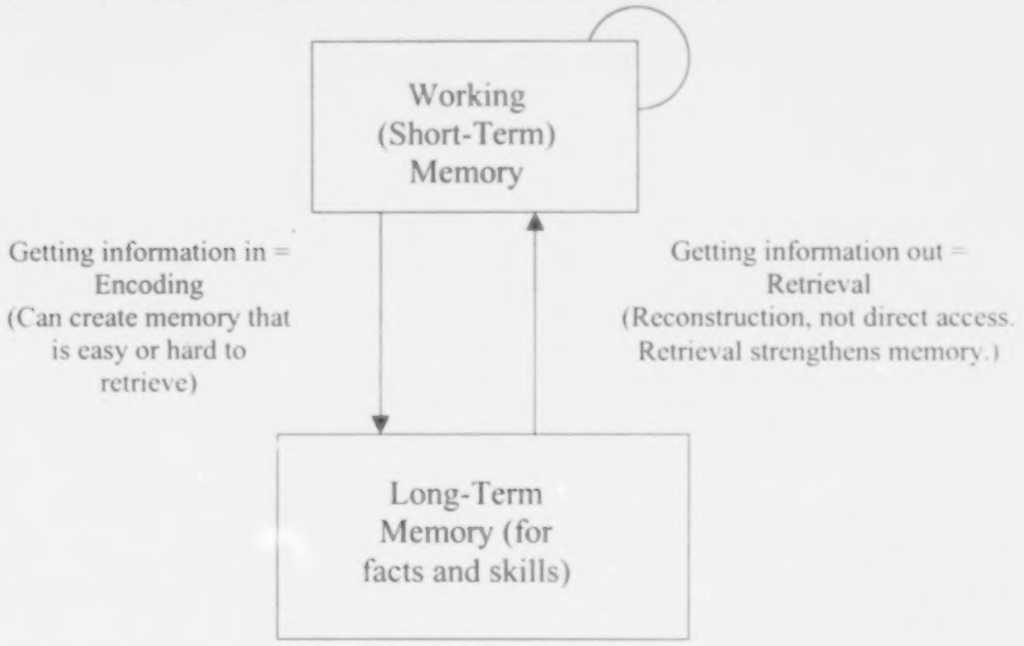
Getting Information In And Out

The diagram below shows several important facts about memory that are covered in different fact sheets:

- Information goes through working (short-term) memory before it can be stored in long-term memory (Fact Sheet 7).
- There are ways of getting information into long-term memory (encoding) that make the memory easier or harder to get out (retrieve) later on (Fact Sheet 5).
- The act of remembering (finding and pulling information out of long-term memory) makes the memory stronger and easier to retrieve later on (Fact Sheet 8).


Working (Short-Term) Memory
Getting information in = Encoding (Can create memory that is easy or hard to retrieve)
Getting information out = Retrieval (Reconstruction, not direct access. Retrieval strengthens memory.)
Long-Term Memory (for facts and skills)

ADULTS
Adults may have mistaken ideas about memory (such as the sponge model—soak up information until your mind is full) that can get in the way of their using the best ways of learning.

Two Systems

Memory seems to be made up of at least two parts:

- Working memory where information is used while we are thinking (some researchers still call it short-term memory) and
- Long-term memory where information is stored permanently (although we cannot always remember it when we want to!).

Working memory is where we understand. Long-term memory is where we remember.[2] Working memory and long-term memory interact constantly. Information does not just go into

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working memory and then into long-term memory. Information is constantly moving back and forth.[3] For example, if you hear a bird, your past knowledge of birds is activated from your long-term memory.

☞ Pigeons, rats, and monkeys also have both working memory and long-term memory.[4] There are brain injury patients who remember the past but cannot remember anything that happened recently,[5] and ones who remember things that happened recently but cannot remember anything from the past.[6] This shows that there are two different systems, each of which can work without the other.

☞ People remember what they heard at the beginning of a list and end of a list better than what they heard in the middle.[7]

☞ The next two fact sheets go into more detail about working memory (Fact Sheet 7) and long-term memory (Fact Sheet 8). There are different implications for teachers from the two different systems. In this fact sheet, you will find evidence that there are in fact two different memory systems.

☞ The studies on working memory and long-term memory in the next two fact sheets also show that these two systems are very different from each other. For example, working memory is small and stores information quickly, but information is also quickly forgotten.[8] Long-term memory can store huge amounts of information but the information is stored and pulled out much more slowly.[9]

Summary

1. Memory is necessary for learning, but there is much more to learning than just remembering.
2. People remember best what they learn at the beginning and end of a class.
3. Memory is not one system, but a group of systems, including short-term (working) memory and long-term memory.

What it means for teachers

Teach the most important information at the beginning of your class to take advantage of better learning at the beginning. Use the rest of the class for students to practice, apply, and reinforce. End the class with a summary to take advantage of better learning at the end.

Students may be able to "take in a lot of information at once" (good working memory) but not remember it during the next class (poor long-term memory). Or, they may not be able to "take in" much information at one time (poor working memory), but can remember it all well at the next class (good long-term memory). You will find many techniques you can use for relating teaching to students' life experiences in the memory fact sheets. Students may benefit from understanding their own memory strengths and weaknesses.

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Lesson ideas

✍Teach your students about working memory and long-term memory:

✍Try some of the classic memory experiments in class. Read a list of 15 vocabulary words that will later appear in a reading passage. Ask students to remember as many as they can. Do they remember the first few and last few words better? This can become a graphing exercise.

✍Ask students what they know about memory (students may already know about amnesia, brain damage [from accidents, drugs, or alcohol], or Alzheimer's disease).

✍For a writing exercise, ask students if they think they have a good memory or bad memory and why. You may need to help students think more broadly than just things they learn in class—are they good at remembering names of friends or celebrities, appointments, relationships (on soap operas!), directions, recipes, or new words they hear?

NOTES

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Fact Sheet 7: Working Memory and Learning

Principle: Working Memory Helps All Learning

> "Without learning, there is nothing to remember, and without memory, there is no evidence of learning."— Kay L. Huber, Nursing Professor[1]

Questions for teacher reflection

- How do you remember a phone number after looking it up in a phone book?
- Do your students ever get to the end of a sentence and forget what the beginning of the sentence was about?
- Do your students move their lips when they read?
- Read the following letters once, cover them up, and try to repeat them: DTCVBG. How many did you get in the right order? Try it again with these letters: RHXKWY. How many this time? Was there a difference? Why?

What we know

7±2 Slots

☞ Working memory is really just a name for information that is being used while we are thinking. You can think of it as the parts of your long-term memory that are being used right now.[2] Working memory has a lot of limits--it lasts for 10-30 seconds, and it can hold only about 7 letters or numbers, fewer words, and even fewer sentences at a time.[3] Working memory can hold organized information much better than disorganized information.[4] For example, you may be able to remember the number of days in each month better with the rhyme, "Thirty days hath September . . . " than by going through each month, "January—31, February—28, . . ."

Gatekeeper For Learning

☞ Working memory has been called a gatekeeper for learning—you can only learn as many things at one time as you can fit in working memory. Beyond that, other information never makes it into working memory until you have processed the information that is there.

Information And Processing Compete For The 7 Slots

☞ Working memory includes both information and thinking. It can hold a lot of information and do some thinking, or a little information and a lot of thinking.[5] For example, you could easily hold six single-digit numbers in working memory and add them up. But you probably would overload your working memory if you had to do calculus with those same numbers. This is one reason why people with small vocabularies have trouble reading. The new vocabulary words take up space in working memory, so there is not much left to figure out the meaning of the

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sentence. Working memory is also much smaller if people have to calculate while they try to remember a list of words, but not if they just have to tap a pencil.[6] This is because doing math at the same time as remembering uses up limited thinking resources.

☞ The thinking and linking parts of working memory, not storage space, seem to be the most important ones for reading.[7] Slow readers and fast readers show a big difference in working memory—slow readers use most of working memory to decode words, so they lose a lot of the information they just read. Fast readers use very little working memory to decode, so they can keep much more information (more sentences) in mind at the same time.[8]

Link To Students' Knowledge Base In Long-Term Memory

☞ Working memory uses both new information and knowledge from long-term memory like vocabulary (word meanings), word sounds, and background knowledge.[9] The mind searches for the meaning of a word as soon as it is read, so part of reading time is finding the meaning of the word. Good readers connect the word on the page with its meaning faster, so they read faster. They also:

- have less trouble with words that could have several meanings, all of which need to be kept in mind, and
- are better at remembering information from a previous sentence, which helps both reading comprehension and logical reasoning.[10]

People who are better at reasoning also have better working memories than those who are not as good at reasoning.[11] We do not know if they are born with better short-term memories, or if they have better short-term memories because they have had so much practice with problem solving.

☞ Working memory and long-term memory are connected—working memory has to pull word patterns and word meanings from long-term memory.[12] For example, when you hear a word, you recognize it from your own long-term memory. Real words are remembered better than made up words, like "maffow." Common words are remembered better than uncommon words. People also read real words faster than made-up words and more "word-like" made-up words faster than less "word-like" ones.[13]

Not A Place In The Brain, But A Kind Of Processing

☞ Working memory is not a place in the brain. MRI scans show that many different parts of the brain are active whether we are thinking (working memory) or recalling (long-term memory). Working memory also includes visual information, and, for deaf people, sign language information.[14] So working memory is a complex bundle of thinking, new words, background knowledge, visual, and other information.[15]

Talking To Myself Again . . .

☞ A word can last in working memory for about 2 seconds without any work. To keep a word in working memory, you need to rehearse it, as in the example above of remembering a telephone number. Working memory stores words using a kind of "talking to yourself" (although your mouth does not have to move to do this).[16] We know this because:

1. Working memory mistakes tend to be letters that sound the same, not letters that look the same, even if the words are read silently.
2. Working memory is much smaller if people have to repeat a nonsense syllable like "tah-tah-tah" while they try to learn a group of letters. Speaking out loud interferes with the "silent speech" used by working memory.
3. Working memory is also smaller if there are background sounds of speaking, music, or noise that sounds like speech, but not from "white noise."[17]

Children under five do not make the same kind of errors, so it seems they do not use "silent speech."[18]

☞ This "talking to yourself" can be just repeating the words, or it can include making connections between the things you need to learn. Repetition is needed when the list is arbitrary, like times tables or a spelling rule. Making connections is a more effective way to remember, when it is possible to connect new information to what you already know.[19] Some memory techniques work because they make a connection between a new word and something well-known like a number.

ADULTS

Adult students may think that repeating something over and over again is a good way to learn it. In fact, this is a good strategy for remembering what to pick up at the grocery store, as long as you keep repeating it. But as soon as you stop saying it, you are likely to forget the information. So repeating is good for short-term memory, but not for long-term learning.

How Does It Affect Learning?

☞ Working memory is crucial for reading, understanding what we hear, and solving problems.[20] Working memory keeps the beginning of a sentence in your mind until you get to the end of the sentence and make sense of it, in both reading and listening. People with working memory damage (from surgery, seizures, or brain injuries) have trouble reading or understanding long sentences.[21] Children who have trouble learning to read, people with learning disabilities, and people who do not have good reading comprehension all tend to have poorer working memory.[22]

☞ Working memory is also related to reading in another way. To read, a person must first understand that spoken words are made up of distinct sounds.[23] The word "night" is made up of three sounds—"n," "I," and "t." These sounds are part of your long-term memory, along with the common sound patterns of English (word families like "night," "fright," "light"). Some children who have trouble hearing the separate sounds in a word have poor short-term memory. Listening comprehension matches reading comprehension pretty closely.[24] Children with dyslexia are slower at deciding whether two letters (such as AA or AB) match.[25]

☞ Reading, of course, involves a lot more than working memory. It includes figuring out vocabulary from context, inferring unstated facts, following a plot, and using background knowledge, among other things. But if sound patterns never make it into long-term memory, then learning new words and decoding words on the page become very hard.[26]

ADULTS

☞ Adults' working memory is larger than children's. This may be because children have not developed as much of a sense of the patterns of English, including how common certain words are.[27] Unlike long-term memory, the size of short-term memory does not depend on background knowledge.

☞ Working memory is more efficient if new information is linked to what you already know. For example, a word in a list is easier to remember if you already know the meaning of the word. This means that working memory depends on how much you have learned. Being able to "chunk" information so that it is easier to understand also depends on what you already know. You cannot reorganize a list to make it easier to remember if you do not know the categories to sort it into.[28]

Reading Disabilities And Working Memory

☞ Many studies show that a lot of students with reading disabilities have short-term memory problems. Although they can learn non-verbal information and concepts quickly, more than other readers, they:

- tend to have smaller short-term memory for words,
- tend to have trouble keeping word lists in order,
- tend not to rehearse words ("talk to themselves") as much,
- tend not to organize lists of words as much (especially when there are time limits), and
- tend to have trouble repeating made-up words after hearing them.

Students with reading disabilities benefit more from learning self-talk and organizing strategies than other readers do.[29]

Teaching Students To "Chunk" Information

☞ People can learn to organize information in working memory better. Research from brain injuries suggests these steps:

- Explain how the memory skill can help students learn, since it may seem silly at first (e.g., explain that the "i before e" spelling rhyme can help them spell better).
- Figure out how well students can remember now (a spelling quiz with "ie" words).
- Teach the new skill and practice it (maybe over several classes, using examples and practice).
- Extend the skill to student goals ("ie" words on a practice GED grammar test).

Memory skills that can be improved by training include organizing items by putting them into categories and remembering lists, rules or instructions using rhymes, key words or visualization.[30] You will find some specific methods under "lesson ideas" below.

☞ After training, the size of working memory stays the same, but each "chunk" of memory can hold more information. Improvements in one skill do not spread to others. For example, improving working memory for numbers does not help working memory for letters.[31]

☞ Working memory increases as reading skills improve. This is probably a complicated process including better chunking, a better sense of the sounds of English, more efficient and automatic thinking skills, and a bigger knowledge base in long-term memory.

☞ Here we have only touched the tip of memory and learning. The next fact sheet on long-term memory has strategies for moving information from working memory into long-term memory and strategies for remembering information that was learned before.

Summary

1. Short-term memory has 7 ± 2 slots. It can hold seven numbers, about five words, about three nonsense syllables.
2. Short-term memory is a gatekeeper for learning. Information beyond the seven items is not processed.
3. Information and processing compete for the seven slots.
4. There is a link to students' knowledge base in long-term memory.
5. Short-term memory is not a place in the brain, but a kind of processing.
6. Short-term memory uses "self-speech" (self-signing for deaf), so there are sound-alike errors. Simply repeating a word over and over again keeps it in short-term memory but does not move it to long-term memory.
7. We can teach students to "chunk" information so that more slots are available.
8. Writing frees up short-term memory.

What it means for teachers

"The implications of working memory limitations on instructional design can hardly be overestimated."—Sweller, van Merrienboer, and Paas.[32]

Don't Overload Students

🔑 Do not overload students with too much information before they have a chance to think about it. Just asking students if they have any questions gives them time to think about what they have just heard.[33]

Teach Students To "Chunk"

🔑 Teach students to organize or "chunk" information in lists.[34] Training can have an amazing effect on working memory. One college student learned to keep 79 digits in his head (after training for almost two years) by relating the numbers to world records for runners. In the same study, students who could not associate the numbers to something they already knew could not increase their short-term memory.[35]

- Taking notes or making a summary is a very good way for students to "chunk" information from a lesson.[36]

- Teach memory tricks that relate new information to what students already know. This is a form of "chunking."

Improve Students' Knowledge Base

- Improving short-term memory may improve students' knowledge base, which is vital for real learning. The new vocabulary then helps students master new material, instead of falling behind.[37]

- Notes, discussions, and in-class practice are important ways to connect new information with what students already know.[38]

Reading And Word Sounds

- It may be harmful to prohibit students from moving their lips when they read. Silent reading is relatively new in human history (probably since the 1800s),[39] and reading aloud may be much easier than reading silently, although it is slower.[40]

Write Things Down To Free Up Working Memory

- Write down assignments so that students who have trouble keeping all of the parts of the assignment in their heads will be able to understand what the homework is.

- When students are working on a complicated problem, write down the whole problem on the board or on paper. This frees up working memory to do the thinking part of the problem.

Other Implications

- Some problem-solving strategies can use up a lot of working memory, such as looking at the question and finding a formula that includes that variable. Consider giving questions with open-ended answers, so that students will not overload working memory with these poor strategies.[41]

- Do not teach two easily confused ideas in the same lesson, like "affect" and "effect." Be sure that students have totally mastered one before teaching the other.[42]

- It is possible that drawings or other visual memory tools may help students who have poor short-term memory for words.[43] Drawings can include characteristic details (like scales on a fish); have drawings of keywords that sound or look like the word to be remembered ("camel" for "mammal" or "bib" for "amphibian"); or include letter memory aids (like ROYGBIV for the colors of the rainbow).

Students who have serious short-term memory problems with words will have a very hard time understanding what they read and may have trouble learning to sound out words. Remember, however, that reading involves a lot more than short-term memory.

There may be some short tests (less than an hour) than can help separate students who have reading problems because of processing problems from those who had bad instruction or have been out of school for many years.

Lesson ideas

In spelling, encourage students to think of parts of the word, not just letters. For example, "There is a 'rat' in separate." "Similar" can be learned as "simi" and "lar," (2 chunks) not as s-i-m-i-l-a-r (7 chunks). Another option for mothers would be "Similac™ [a brand of infant formula] with an r instead of a c." In California, use Simi Valley, etc., etc.

Give students a short-term memory task and ask them why they think the mind might have limits on short term-memory (to avoid overload), and how it affects learning.

Draw pictures that help relate new information to what students already know. For example, for the word acknowledge (ac-know-ledge) you could draw a brain (know) on a window ledge saying "Thank you." Pictures work best if the parts interact, although they do not have to be absurd.[44] Although these kind of memory tricks may seem silly, they are proven to work if you connect an unknown word with an idea the student already knows.[45]

Use rhymes, sayings, or songs to remember lists of arbitrary facts or rules after students have reviewed the list or rule.[46] Do you remember, "Two times two is four for sure" from math, "King Phillip Came Down . . ." from biology, ROYGBIV from physics, or "Every Good Boy Does Fine" from music lessons? Encourage students to make up their own memory tricks.

Write items that need to be memorized onto index cards and help students sort them into categories. Then have the student memorize the categories. For example, in the "i before e" rule, sort "ie" words into one pile, "cei" words into another, and exceptions into a third pile.

After reading a passage, teach students how to take notes and summarize the passage. You may want to provide a note-taking outline with room below each point for students to fill in their notes.

NOTES

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[1] Huber, K.L. (1993). Memory is not only about storage. *New Directions for Adult and Continuing Education, 59,* 35-46.

[2] Reisberg, D. (1997). *Cognition: Exploring the science of the mind.* New York: W.W. Norton, p. 135 and Jonides, J. (1995). Working memory and thinking. In E.E. Smith & D.N. Osherson (Eds.), *An invitation to cognitive science, Vol. 3: Thinking, 2nd Ed.* Cambridge, MA: MIT Press. There is still some controversy over short-term memory. A competing model called the Atkinson-Shiffrin model seems to have been replaced by Alan Baddeley and Graham Hitch's working memory model, based on early research by R. Conrad. The Baddeley and Hitch model is now

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being revised as well. Baddeley alone was the author or co-author of more than 50 publications on memory from 1966 to 1990.

[3] Miller, G.A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63* (2), 81-97. Some researchers argue for fewer chunks: Ericsson, K.A., Chase, W.G. & Faloon, S. (1980). Acquisition of a memory skill. *Science*, 208, 1181-1182.

[4] Slavin, R. (1997). *Educational psychology: Theory and practice, 5th Ed.* Boston: Allyn and Bacon, p. 190.

[5] Daneman, M. & Carpenter, P.A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior, 19*, 450-466 and Just, M.A. & Carpenter, P.A. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review, 99* (1), 122-149.

[6] Cantor, J. & Engle, R.W. (1993). Working memory capacity as long-term memory activation: An individual-differences approach. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19* (5), 1101-1114 and Vallar, G. & Baddeley, A. (1982). Short-term forgetting and the articulatory loop. *Quarterly Journal of Experimental Psychology, 34A*, 53-60. Simple tests of how many numbers you can remember (called a digit span test) do not predict reading comprehension, except in severely mentally retarded readers. The digit span test only measures storage space in working memory, not processing ability.

[7] Masson, M.E. & Miller, J.A. (1983). Working memory and individual differences in comprehension and memory of text. *Journal of Educational Psychology, 75* (2), 314-318.

[8] Daneman, M. & Carpenter, P.A. (1983). Individual differences in integrating information between and within sentences. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 9* (4), 561-584.

[9] Baddeley, A., Logie, R. & Nimmo-Smith, I. (1985). Components of fluid reading. *Journal of Memory and Language, 24*, 119-131.

[10] Daneman & Carpenter. Individual differences in working memory and reading.

[11] Kyllonen, P.C. & Christal, R.E. (1990). Reasoning ability is (little more than) working memory capacity?! *Intelligence, 14*, 389-433.

[12] Gathercole, S.E. & Martin, A.J. (1996). Interactive processes in phonological memory. In S.E. Gathercole (Ed.), *Models of short-term memory*. Hove, England: Psychology Press.

[13] Baddeley, A. (1986). *Working memory*. Oxford: Clarendon Press, p. 177.

[14] Shand, M.A. (1982). Sign-based short-term coding of American sign language signs and printed english words by congenitally deaf signers. *Cognitive Psychology, 14*, 1-12.

[15] This is an area with a great deal of controversy—some argue for a unitary system (Gathercole, S., Engle, R.W., Cantor, J. & Carullo, J.J. (1992). Individual differences in working memory and comprehension: A test of four hypotheses. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18* (5), 972-992.); some for three systems (an "executive," a visual rehearsal system, and a word rehearsal system—Baddeley); others have proposed adding a movement or motor rehearsal system [Jorm, A. (1983). Specific reading retardation [reading disabilities] and working memory: A review. *British Journal of Psychology, 74*, 311-342.] or a very short-term conceptual memory linked to long-term memory [Potter, M.C. (1993). Very short-term conceptual memory. *Memory and Cognition, 21* (2), 156-161] in addition to these three. Some brain injury and MRI studies seem to show there can be damage to one area (e.g., articulatory) and not to others (e.g., visual), which supports the idea of several systems [Baddeley, A. (1996). The concept of working memory. In S.E. Gathercole (Ed.), *Models of short-term memory*. Hove, England: Psychology Press.].

[16] People who were born without the ability to speak show the same kind of interference with "silent speech" that speakers do.

[17] Called 1) "phonological similarity," 2) "articulatory suppression," and 3) the "unattended speech effect." A comprehensive review is in Baddeley, A. (1998). *Human memory: Theory and practice, Rev. Ed.*, Boston: Allyn & Bacon, Chapter 4. Some researchers think these three effects have to do with attention, but the weight of the evidence seems to point to an "inner voice." See A. Jorm. Specific Reading Retardation.

[18] Cowan, N. & Kail, R. (1996). Covert processes and their development in short-term memory. In S.E. Gathercole (Ed.), *Models of short-term memory*. Hove, England: Psychology Press.

[19] Called "maintenance rehearsal" and "elaborative rehearsal." McCown, R., Driscoll, M. & Geiger-Roop, P. (1996). *Educational psychology: A learning-centered approach to classroom practice, 2nd Ed.* Needham Heights, MA: Allyn & Bacon, p. 214. Also see Ericsson et al. Acquisition of a memory skill.

[20] Nairne, J.S. (1996). Short-term/working memory. In E.L. Bjork & R.A. Bjork (Eds.). *Memory*. San Diego: Academic Press.

[21] Baddeley, *Human memory*, p. 66.

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[22] Snow, C.E., Burns, M.S., & Griffin, P. (Eds.). (1998). *Preventing reading difficulties in young children.* Washington, DC: National Academy Press.

[23] These basic units of speech are called "phonemes." The skill of hearing them is called "phonemic awareness." Snow et al., *Preventing reading difficulties*, p. 51.

[24] Morais, J., Alegria, J. & Content, A. (1987). The relationships between segmental analysis and alphabetic literacy: An interactive view. *Cahiers de Psychologie Cognitive, 7,* 415-438, and Baddeley et al. Components of fluid reading.

[25] Ellis, N.C. & Miles, T.R. (1978). Visual information processing in dyslexic children. In M.M. Gruneberg, P.E. Morris & R.N. Sykes, (Eds.), *Practical aspects of memory.* London: Academic Press.

[26] Gathercole, S.E. & Baddeley, A.D. (1990). Phonological memory deficits in language disordered children: Is there a causal connection? *Journal of Memory and Language, 29,* 336-360.

[27] Cowan & Kail, Covert processes. This is another contentious area—some have argued that adults have a larger working memory (Pascual-Leone), some that adults have more and better thinking strategies (Chi), some that adults process faster (Kyllonen & Christal) or more efficiently (Just & Carpenter), and some that adults use "inner speech" better (Baddeley).

[28] Kintsch, W. (1998). *Comprehension: A paradigm for cognition.* Cambridge, England: Cambridge University Press and Halford, G. (1993). *Mental models.* Hillsdale, NJ: Erlbaum, p. 273.

[29] Jorm, Specific reading retardation [reading disabilities]. It is not clear whether the memory problems cause the reading problems; an underlying language problem causes the memory problem; or doing little reading leads to poorer memory.

[30] Parente, R. & Herrmann, D. (1996). Retraining memory strategies. *Topics in Language Disorders, 17* (1), 45-57.

[31] Ericsson et al. Acquisition of a memory skill.

[32] Sweller, J., van Merrienboer, J.J.G., & Paas, F.G.W.C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10* (3), 251-296, p. 252.

[33] Bruning, R.H., Schraw, G.J. & Ronning, R.R. (1995). *Cognitive psychology and instruction* (2nd Ed.). Englewood Cliffs, NJ: Prentice Hall, p. 77.

[34] Bruning et al., *Cognitive psychology and instruction*, p. 78.

[35] Ericsson et al. Acquisition of a memory skill.

[36] McCown, Driscoll & Geiger-Roop, *Educational psychology*, p. 213.

[37] Scruggs, T.E. and Mastropieri, M.A. (1992). Remembering the forgotten art of memory. *American Educator, 16* (4), 31-37.

[38] Borich, G. & Tombari, M. (1997). *Educational psychology: A contemporary approach.* New York: Longman, p. 154.

[39] Crowder, R.G. & Wagner, R.K. (1992). *The psychology of reading: An introduction, 2nd Ed.* New York: Oxford University Press, 157-161.

[40] Baddeley, *Working memory*, p. 176.

[41] Sweller, van Merrienboer & Paas, Cognitive architecture and instructional design.

[42] Slavin, *Educational psychology*, p. 199.

[43] Levin, M.E. & Levin, J.R. (1990). Scientific mnemonomies: Methods for maximizing more than memory. *American Educational Research Journal*, 27(2), 301-321.

[44] Reisberg, *Cognition*, p. 426.

[45] Levin & Levin, Scientific mnemonomies. Previous research that memory tricks, or mnemonics, lead to surface learning, not deep thinking, have been largely disproven.

[46] Huber, Memory is not only about storage.

Fact Sheet 8: Long-Term Memory and Learning

Principle: Long-Term Memory Is A Web

> "Memory is not like a muscle, and thus cannot be improved just by repetitive practice. Only the acquisition of more effective memory strategies will enhance memory."—Alan Parkin, memory researcher[1]

Questions for teacher reflection

- What is your model for how the mind stores information?
- What do you do when you need to remember something you are learning for a class?
- Do you think the mind stores information like a filing cabinet? In what ways? What would that mean for teaching?
- Do you think the mind stores information like a computer? In what ways? What would that mean for teaching?

These questions got you thinking about long-term memory.

What we know

Studying Memory

☞ As teachers, we want to know how memory works so that we can help students learn better. We want to help them get information into memory better and also be better able to get information out of memory. But studying memory is a bit different from studying thinking. We can ask people how they solved a problem, but we do not learn as much when we ask people to remember things. Most of the time they just say "I remembered it." So the research on memory is very indirect, and most of it measures how long it takes people to recall facts from memory. These studies tell us about how the mind stores information; then we can base our teaching on what we know about how the mind works.

Models Of Memory

☞ Is memory like a filing cabinet or is it like a computer? And what does it matter to teachers or students?[2] Some new findings about how the mind stores information can help us teach in ways that students will remember better. More information about long-term memory is in Fact Sheet 5: Getting Information into Memory and Fact Sheet 3: Mental Models.

Traveling On The Information Network

☞ One way to figure out how memory works is to find out how long it takes to get information out. That is, some questions can be answered quickly and some are much slower. The pattern of fast and slow answers should tell us something about how information is stored. For example, it takes people about 1.39 seconds to answer "True" to the statement "A canary can fly." It takes

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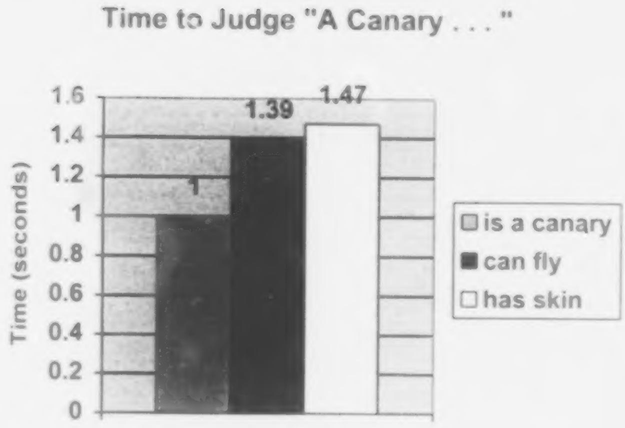
about 1.47 seconds to answer "True" to the statement "A canary has skin." It is quicker for the mind to get from "canary" to "flies" than to "has skin."[3] (This does not mean there is a canary nerve cell in the brain that is physically closer to a "flies" nerve cell than to a "has skin" nerve cell.) This suggests that the mind does not store information randomly, like a computer. In a computer, the first information that goes in is stored in the first available space, and later information is stored in the next available space. Clearly, memory is stored in a much more organized way in the human mind.



Information is stored in an organized way in memory.

Organized Storage

☞ Another way to figure out how memory works is to compare real words and nonsense words. Real words should be stored in the mind in some kind of organized way, and words that are related to each other should be easy to get to. Nonsense words should not be stored at all. People were shown one real word (or nonsense word), then another word (or nonsense word), and asked whether both were real words:

First "word"	Second "word"	Answer	Time to decide
bread	butter	Yes	.855 second
nurse	butter	Yes	.940 second
wine	plame	No	1.087 seconds
plame	wine	No	.904 second
plame	reab	No	.884 second[4]

So real words are quicker to get to, and related words are quickest of all. This is more evidence that information is organized in the mind.

Associations

☞ This study shows another related point. From these studies we could imagine all of our familiar words "crowded up in front" of the mind, like a filing cabinet with all of the most commonly used files up front. Maybe "flies" is quicker to get to than "has skin" because it is just a more common concept overall. But here, "butter" and "nurse" are both quite common words, and it took longer to get to "butter" after "nurse" than to get to "butter" after "bread." This shows that information is stored in memory by **associations**.[5] In this way, memory is like a giant spider web, where every piece of information is connected in many different ways.

To learn anything, a student has to associate it to something that he or she already knows.

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Concepts And Typical Examples

☞One way that memory works is through concepts, or generalizations, about how things are in the world. Instead of storing information about "greyhound dogs," "Chihuahua dogs," and "boxer dogs," the mind can store information about the concept, "dogs" and associate greyhound, Chihuahua, and boxer with it. The mind also stores information about how typical an object is. For example, a robin is a typical bird, and a penguin is a non-typical bird. Decisions are quicker if an item is considered "typical." For example, "chair" and "sofa" are very typical pieces of furniture, but "rug" and "cupboard" are less typical. So it is quicker to decide whether "chair" and "sofa" are both furniture than to decide whether "rug" and "cupboard" are both furniture. The mind does not use dictionary definitions; rather it uses "fuzzy categories." Memory includes **concepts** and information about how **typical** things are.[6]

Characteristic Features

☞ How does memory store things like a penguin, a bird that does not fly? What happens when associations conflict with each other? Our idea about memory so far would say that "penguin" is associated with "bird," and "bird" with "flies." But whenever we think of a penguin we also think of the things that make it different from other birds--things that make it stand out in a crowd, like black and white feathers; short, stubby wings; and does not fly. So some of the things we associate with "penguin" are what makes it like other birds (**defining features**) and some things are what makes it different from other birds (**characteristic features**).[7]

☞So it is not surprising that typical objects (like a pear), are quickly put into a specific category (fruit), and slowly put into a more general category (food). But atypical objects (cantaloupe) are actually quicker to put in a general category (fruit) than into a specific category (melon):

Item	Category	Time	Is it typical?
Pear	Is it a fruit?	889 milliseconds	Yes
	Is it a food?	1,164 milliseconds	No
Cantaloupe	Is it a fruit?	974 milliseconds	No
	Is it a melon?	1,174 milliseconds	Yes[8]

*When students learn something new, they are storing **facts**, information about **categories** (how the new information is linked to other information), and how **typical** the new information is.*

Activating Memories

☞Another key to how memory is organized comes from studies of repeated letters. When two letters are flashed on a screen (such as AA or AB), it takes time for people to decide if they are the same or not. But if the person has seen the letter recently (A before AA), he or she will decide much more quickly.[9] The same is true of words: in one study, only 34% of new words were recognized, but 70% of repeated words were recognized (rare words were used).[10] The idea is that information **activates** part of your memory. For example, if you read about wheat and then later about bread, you can read faster that if you had not read about wheat first. Reading about wheat activates your memory for wheat, which is connected to bread, and which activates bread in your memory. You can then understand the information about bread faster because it has already been activated.[11]

Students understand better when they have a pre-reading discussion or read about familiar topics because information is already activated in their memories.

Relating New Information To What You Know

☞ Just seeing new information is not enough for learning most of the time.[12] The mind has to do some work with new information before it will be reliably stored in memory.[13] For example, the mind can try to make sense of a sentence, compare a new image to a familiar one, or fit new information into a known concept. Relating new information to known even works for people with amnesia.[14] This work moves information from working memory (where it will only last 20-30 seconds) into long-term memory.[15]

☞ For example, people who are asked to relate new information to what they know ("what does this make you think of, are there other words that sound like this?") remember about 72% of the words after 12 seconds. People who are asked to repeat the words over and over again (rote learning) remember about 35% of the words. Most people who are asked to "just remember" repeat the words and only remember about 5% more than those who are told to repeat. In this study, making connections created another way to remember the information later on.[16]

☞ In the same study, people who repeated words tended to make "sound-alike" mistakes (like "late" instead of "mate"), but people who related words tended to make "means alike" mistakes (like "talk" instead of "say"). In other words, the mind seems to be remembering in different ways when we repeat words than when we relate words.[17]

☞ In another study, people were asked to write down three words to describe a word they were learning (for example, marmalade: sticky, sweet, can be eaten) for 500-600 words. Later, they could remember 50-60% of the words after hearing one word from their own description (sticky) and 90% of the words after hearing all three (sticky, sweet, can be eaten). People who did not write down the words guessed 5% of the words after hearing one describing word (sticky) and 17% of the words after hearing all three (sticky, sweet, can be eaten).[18] In this study, thinking of descriptions created another way to remember the information later on.

☞ People tend to learn by repeating when they know they can keep repeating until they have to remember. But they tend to associate when they know there will be some time before they have to remember.[19]

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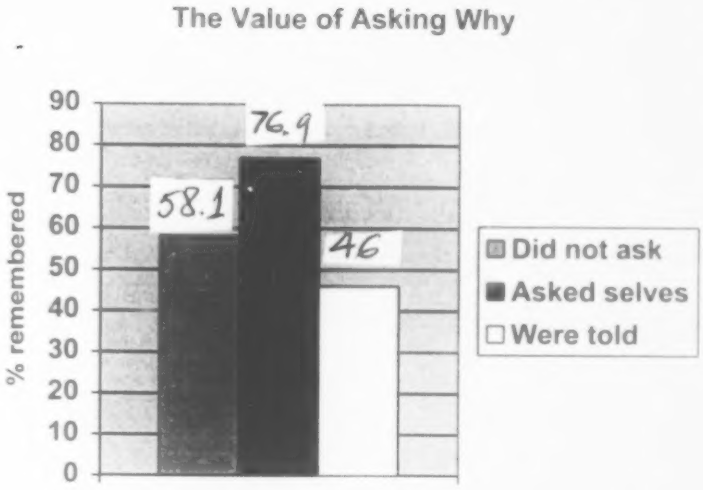
☞ We can teach students to make these connections for themselves. For example, college students who were taught to ask themselves why something in a text was so remembered 33% more than students who were not taught. For example, given the sentence "The dying man used a feather," students might say, "The dying man used a feather to sign his will." Students who were told the connections remembered even less than students who were just asked to remember the short sentences. In other words, giving students the answer got in the way of their learning![20]



ADULTS
Although adults clearly have more life experience than children, many adult literacy students do not have a large base of factual knowledge to relate new information to. For example, if they do not know anything about garden vegetables, we cannot help them learn about trees by relating this new information to vegetables.

Memory for Organized Information

☞ People remember and learn better when they get organized information.[21] If they are given a disorganized list (such as muskrat, blacksmith, panther, baker, wildcat) people will repeat it back in a more organized way (muskrat, panther, wildcat, etc.).[22] This means that the information is organized in the mind as it is remembered. In another study, people who got an organized chart remembered more than twice as many items as people who got the same information in a disorganized chart.[23] For example, with an organized chart (such as minerals → metals → rare; common; alloys) people remembered an average of 90% of the words. With a disorganized chart (such as rare → alloys → metals; common; minerals), people remembered only an average of 41% of the words. The categories on the chart helped people to learn the information in the first place.

☞ In another study, people heard organized lists of 48 words with categories (such as "articles of clothing: blouse, sweater"). People who later had the categories repeated to them remembered about 75% of the words. People who did not have the categories repeated later only remembered about 40% of the words. The category names helped people remember later.[24]

☞ One way to organize learning for students is to give them an outline before they read. For example, students who read an easy passage that explained computers before reading a computer programming text answered 52% of the programming questions right. Students who just read

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about programming answered 42% of the questions right.[25] Outlines work well for topics that have an organized structure, like supply and demand in GED economics. They do not work well for history, where there is no internal structure except time. And they only work well if students already know something about the topic.[26]

Ways In and Ways Out

☞Students can have problems when they do not store lessons in memory or when they cannot get the information out. To get information out, it helps to have a clue (what researchers call a cue) that reminds you of the thing you want to remember. For example, there may be a CD that you listen to a lot. You may not be able to name each song in order, but when you are listening to the CD, the end of one song reminds you of what song is coming next. The end of one song is a memory cue for the next song.

☞One important finding is that information that goes in strongly is easy to get out; information that goes in weakly is hard to get out.[27]

When information goes in . . .	It can be gotten out . . .
Strong--Learning for understanding Relating new information to old Making connections	**Weak or strong** Strong (most likely to get right)--questions that are the same as the reading, questions that are the same as the learning situation, multiple choice, recognize familiar words. Weak--questions that ask you to apply the information in a new way, open-ended essay questions, remembering lists, facts (not just recognizing them on a list).
Weak--Memorizing, rote learning, meaningless repetition	**Strong only**--questions that are the same as the reading, questions that are the same as the learning situation, multiple choice, recognize familiar words.

☞Note that some information always has to be memorized, such as multiplication tables and spelling patterns.

☞Several studies on learning disabilities show that once LD students get information into long-term memory, they remember the same as other readers. The problem is in getting information from print into memory.[28]

Memory Tricks

☞Making a drawing or an acronym, like ROYGBIV for the colors of the rainbow, are very powerful tools for remembering. These memory tricks work by imposing meaning on otherwise meaningless information. They should be saved for arbitrary information that cannot be learned in a meaningful way and must be memorized. They are especially useful for learning vocabulary or lists, and are very powerful for students with learning disabilities.[29] Rhymes are also commonly used to make information easier to remember, like the old chemistry adage, "Do what you ought'er, put the acid in the water" (water poured into a strong acid makes the acid heat up quickly, and can start a fire).

☞Drawings and acronyms work because they are a way to chunk information (see Fact Sheet 7: Working Memory and Learning). Acronyms create a meaningful connection between a short word and the information that needs to be learned. For example, FARM-B can be used to remember the vertebrates (**F**ish, **A**mphibians, **R**eptiles, **M**ammals, and **B**irds). FARM-B is short, and it is connected in a meaningful way (first letters) to a long list.[30] The acronym creates a second way to get the information out of memory, from "vertebrate" and also from "FARM-B".[31]

☞Drawings are another way to chunk information and create meaningful connections. To remember that "substantial" means "big," draw a mouth biting into a big sub sandwich (if that is what a hoagie, grinder, or hero sandwich is called in your part of the country!) with the word "substantial" next to it. One key part of these drawings is the interaction between the objects.[32]

Automatic Skills

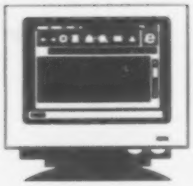
☞Some thinking seems to happen on "autopilot." For example, you may not feel like you need to consciously think through the steps for adding two-digit numbers ("line up the numbers right to left. . ."), any more than you have to think through the steps of how to drive a car ("clutch in, shift, . . . "). In fact, people with amnesia who cannot learn or remember new facts, can learn these kind of skills, such as tracing a star on a piece of paper.[33] So there seems to be a separate part of memory where automatic thinking skills, physical skills, and habits are stored.[34] When we are first learning these skills, we are very conscious of them (and slow), and they appear to be stored with all of our other fact learning. But once they become automatic, it seems they are stored in a different way in the mind.

ADULTS

Adults may expect learning to come effortlessly—they may forget how hard they worked as children to learn new things, or they may think that remembering school subjects is like remembering the movie they saw the night before—effortless. I have found that it helps students to explain to them that what they are learning will take a lot of effort at first, but eventually it will become automatic as it is for us, their teachers.

Memory Is Not Like A Computer

☞The idea that human memory is like a computer, with perfect access to information stored in a particular location, is not an accurate one. With this model, simple repetition would guarantee that information gets into the brain and could be recalled instantly. Students who believe this model may call themselves "stupid" when they fail to learn meaningless material instead of realizing that learning needs to fit the way the mind stores information.[35]



Computer	**Mind**
Enter data once and it is in memory	Need repetition to get into memory
Data must be entered	Need to do work to get into memory
Data can be entered randomly	Some learning just happens (implicit)
Perfect access (information has an address)	Information learned better when it is organized
Access depends on address	Many ways to access, all can fail
Accessible forever	Memories fade over time
Each piece of information is separate	Networks of information in mental models
Relationships created automatically	Relationships created by thinking
The act of retrieving has no effect	The act of remembering makes information easier to get later

Summary

1. Information in the mind is connected. It is not stored as single facts, but in complex networks. New information must be connected in a network before it can be stored.
2. Information is stored in an organized way, not randomly (as in a computer).
3. Concepts are an efficient way to store information. They are not dictionary definitions, but a combination of defining features (what makes a penguin like other birds) and characteristic features (what makes a penguin different from other birds).
4. Thinking about something activates everything else related to that idea. So pre-reading discussions really do help our students read better because we are activating all of the vocabulary and ideas they will read about.
5. Relating new information to what you know is the most powerful way to remember new information. Studies with everyone from four-year old children to college students show that this skill can be taught effectively. Most people will not discover this method on their own—they fall back on the ineffective strategy of saying the information to themselves over and over again.
6. People remember organized information better than disorganized information.
7. When students learn for understanding, even a weak clue (like an essay question) can help them get access to the information. When students memorize, the clues must be almost exactly like what they learned.
8. Memory tricks like visual or keyword mnemonics really do work. They are best for learning random information that really must be memorized.
9. When new skills are learned, it takes a lot of thought and effort to use them, because they are stored in factual memory. Once they become automatic, they take essentially no effort because they are stored in procedural memory.

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What it means for teachers

Teaching Should Be Based On How The Mind Stores Information

- Relate new information to what students know.

- Help students build concepts (see below).

- Teach new memory strategies like idea maps, learning with many senses, and so on.

- Build associations among information that students already have through discussion and practice.

- Give students lots of practice recalling what they know, to build paths out of memory.

- Emphasize how new information is like what students already know and how it is different.

- Activate what students know about a topic before they read (see Fact Sheet 3: Mental Models). For example, ask "We're going to read about banks. What words does that make you think of?"

- Emphasize to students the difference between remembering by repeating (less effective) and remembering by relating (more effective).

- Teach in a way that creates many paths into and out of memory (See Fact Sheet 5: Getting Information Into Memory). For example, relating to what you know, using many senses, and so on.

- Ask questions that build connections: Claire Weinstein and her colleagues suggest these questions: [36]

"What is the main idea of this story?
If I lived during this period, how would I feel about my life?
If this principle were not true, what would that imply?
What does this remind me of?
How could I use this information in the project I am working on?
How could I represent this in a diagram?
How do I feel about the author's opinion?
How could I put this in my own words?
What might be an example of this?
How could I teach this to my [family member]?
Where else have I heard something like this?
If I were going to interview the author, what would I ask her?
How does this apply to my life?
Have I ever been in a situation where I felt like the main character?"

Memory

🔎 It takes time to move information from working memory to long-term memory (at least 8 seconds).[37] Students need time to digest information in class.

Lesson Ideas

Writing

✍ Ask students to write about how they think information is stored in memory.

Categories

✍ For a human biology lesson, ask students to list things that are inside the body, then practice categorizing them according to body systems.[38]

✍ Take a recipe and cut it up so that each ingredient is on one piece of paper. Ask students to sort by meat, vegetables, dairy, spices, or ask them to come up with their own categories.

✍ Take an A to Z article (Betty Debnam's syndicated Mini Page© Sunday children's paper is ideal) and cut it apart. Ask students to sort according to your categories or their own.

✍ Present a set of nested categories, minus one (for example, Winton Marsalis, jazz, music) and ask students to fill in the missing term [trumpet].

✍ Create sets of items with one item that does not fit (for example: fight, light, eight, might) and ask the students to explain which one does not fit. Switch what kind of category you use--words that mean the same thing, colors, pictures (of objects or people), numbers or math problems, words that rhyme.

NOTES

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Fact Sheet 9: How Thinking Develops, Part 1—General and School-Based Development

Principle: Some Development is General, Some is Learned

> "Curriculum is often developmentally inappropriate. . . Perspective drawing is a good example. Perspective drawing is based on a fixed, somewhat arbitrary point of view with a set of inflexible rules. Some students understand the existence of viewpoints other than their own, while others struggle with the idea. . . . We begin with three-dimensional concrete experiences before we attempt any drawing. Then to get from three to two dimensions I have students use a piece of glass as a "window on the world" and markers to trace what they see onto the glass. By the time we start drawing, they've had the opportunity to experience and to think about points of view."—Art teacher Gail Dawson[1]

Questions for teacher reflection

- Do you think that some of your students think in "more advanced" ways than others? How would you describe the "more advanced" or "less advanced" thinking?
- Do you think that your students' thinking skills are even across subjects? If a student thinks in "more advanced" ways in science, does that student also think in "more advanced" ways in math? In literature?
- What teaching methods or types of lessons have you used that helped students develop better thinking skills?

What we know

What Does Child Development Have To Offer?

How does thinking develop? How do children go from not being able to understand what they read (in elementary school) to having sophisticated discussions about it (in high school)? Is the process the same for every normal child? Is the process the same for adult learners? Do adults reading at a 3rd grade level think like 3rd graders? Do adults reading at a 12th grade level think like 12th graders? Unfortunately, we do not have the answers to some of these questions because the research has not been done yet. Most research done on the development of thinking has been done with children under six years old.

ADULTS
Most research on "adult" thinking has been done with college students. Research has not been done on either a) the thinking-skill levels of adults in literacy programs or b) how their thinking develops.

☞ That said, what we know about how thinking develops in children can help us in teaching adults in several ways:[2]

1) One part of development is made up of thinking skills that develop from general experience[3] (like learning a first language or basic memory development). This development is almost identical across cultures and runs on almost exactly the same timetable, finishing around age five. Adult students who are not developmentally disabled will all have these skills.
2) Another part of cognitive development is the thinking skills that people learn in school and from parents. **A large part of what we think of as intelligence is made up of these skills that people learn in school.**[4] These kind of skills do not develop naturally, as many people believe.[5] We know some powerful teaching methods to help students learn these skills. So we can be hopeful that adults can learn to think well, provided we and they are patient enough.
3) Our students probably have many more thinking skills than we realize. Research consistently shows that children have advanced thinking skills, **if the questions are asked in the right way**.
4) There are different periods in the development of thinking when certain teaching strategies and ways of explaining things are more effective than others. There are teaching strategies that can help students make the transition to using the abstract thinking required by the GED more often.

☞ The next two fact sheets look at:
- Some ideas about what the patterns of development are,
- Some ideas about what makes thinking develop,
- Thinking skills that students gain from everyday life,
- Some learning advantages that adults have over children,
- Skills that students lose when they are not in school, and
- Learning disadvantages of many students who grew up in low-educated families.

Thinking Skills That Develop From General Experience

☞ There is a large set of thinking skills that develop in virtually all pre-school children from general childhood experiences. These skills develop from interaction with other people at home, in stores, with family, and so on.[6] The most familiar example is probably learning a first language. Children do not need to go to school to understand and speak their first language, all they need is exposure to language. Although schoolchildren will later learn a huge number of vocabulary words, the spoken grammar of a six year old is almost the same as an adult's. Language learning is very different from reading, which almost no children learn without being taught. The thinking of infants before they learn to speak is almost totally different from the thinking of children and adults once they learn language.[7] Infants' thinking is different because learning language influences thinking and thinking influences language learning.[8]

☞ In addition to language:
- Children are born with a small short-term memory that grows naturally without needing

special lessons.[9]

- Five year olds do not usually repeat things to themselves to remember them, but seven year olds usually do, without being taught to do it.
- Children know that objects are solid and move when they are hit.
- Learning subconsciously (for example, memorizing the words on a sign you see every day) develops before first grade.[10]
- Children's concept of time (yesterday, last week, next month, and so on) develops before they go to school (telling time using a clock is another matter).[11]
- Children have an active fantasy life which they largely leave behind, without needing tutoring in "reality."

This pattern of development is almost identical across cultures and runs on almost exactly the same timetable for all people, finishing by about age five.[12]

ADULTS

☞ Adult students who are not developmentally disabled will all have these language, memory, time, and other skills. Even the lowest-skilled adults have made enormous strides in their thinking since infancy.

☞ For many years, it was also thought that children would "naturally" develop from a more concrete thinking style to a more abstract style and from thinking using specific examples to thinking in terms of categories. Both of these approaches have been seriously challenged by research in the last ten years (which will be discussed below). In fact, it seems that children sometimes think abstractly and use categories on familiar objects from a very young age. However, it takes years of education before they are able to apply these strategies to unfamiliar topics.

Thinking Skills Associated With Schooling

☞ Another part of thinking development is a large set of skills that children get from school and parents.[13] Perhaps the most familiar example is reading.[14] It is very rare for a child to decipher the letter-sound code without any help from a reader. While some children learn to read before they start school, they have a lot of help from being read to, reciting the alphabet, rhyming and playing other word games, playing with letters and writing, and watching programs such as *Sesame Street.*[15]

☞ School provides raw material for development to operate on.[16] Other thinking skills that people get in school include:

- sorting objects into categories;[17]
- transferring learning from one area to another;
- knowing what aspects of a problem or situation to notice or pay attention to;[18]
- awareness of word sounds (phonemic awareness);
- free-recall memory;
- accurate mental arithmetic;
- many abilities that underlie IQ, such as vocabulary and verbal analogies;[19]
- understanding figurative language;

- understanding symbol systems such as reading maps, graphs, charts, music notation, algebra, and so on; and
- developing vocabulary.[20]

These thinking skills do not develop naturally, as many people believe. We know some powerful teaching methods to help students learn these thinking skills. So we can be hopeful that adults can learn a wide range of thinking skills, provided that we and they are patient enough.

ADULTS

☞ Even among college-educated adults, thinking normally continues to develop through adulthood.[21] For example, people do not totally understand that all interpretations reflect a particular understanding of the world and that there are no "objective" opinions until college age or older (if ever).[22] Awareness of one's own thinking and learning develops throughout adulthood.[23] There is limited evidence that this self-awareness can be taught directly.[24]

How Do General Development and School Development Interact?

☞ General development helps young children learn in school; school helps them learn more from their environment. The two parts of development reinforce and influence each other.[25] For example, improvements in memory help fact learning, enriching mental models. These mental models then make it faster to process new information, so skills become automatic, which is part of general development.

☞ In other words, there is not one single "engine of development."[26] Development happens in a complicated interaction between the environment (including school) and the developing thinker.[27]

Even Children Have Advanced Thinking Skills That Are Not Obvious

☞ Research consistently shows that children have advanced thinking skills, **if the questions are about familiar topics and are asked in the right way**.[28] The same is true, in my experience, of adult literacy students.

ADULTS

For example, an adult student who reads at the 5th grade level and who has trouble drawing logical conclusions from a workbook about the human body can still draw logical conclusions about basketball, his favorite hobby.

☞ Even children can reason about:

Multiple perspectives—A three-year-old child knows to turn a drawing toward the adult he wants to show the drawing to,[29] even though he acts very egocentrically in many ways.

Scale models—Three-year-old children can use a scale model of a room to find a toy hidden in a real room,[30] although they cannot use a map to find the toy.

Deduction—A three year old can reason that a) his mother always gets lipstick on the can when she drinks soda, b) the can in the fridge has no lipstick on it, therefore c) someone other than his mother drank from the can,[31] although he cannot solve the same kind of logical problem about an unfamiliar topic.

Abstract categories—Three-year-old children can name colors (the category "blue"), even if there are many objects in a range of shades (a navy shirt, a turquoise poster, a sky-blue toy), although they cannot understand the concept "symmetrical."[32]

Induction—A four year old can reason that if people have a spleen, then dogs have a spleen, too. Yet they also mistakenly infer that if dogs have bones, then worms must have bones.[33]

Motivations of others—Four-year-old children can explain why someone did something based on that person's perception of a situation, even if the child has different information about the situation. For example, a three year old who finds out that a candy box really has pencils in it will say that other people will know there are pencils in the box. A four year old will know that other people will think the candy box has candy in it,[34] although the same child can have trouble understanding why someone might hold an opinion different from his or hers.

Inferences—Four-year-old children can infer that if one kind of dog has a particular organ, all dogs have that same organ,[35] although they probably could not make other scientific inferences.

Cause and effect—Five-year-old children consistently say that an earlier event caused a later event, not the other way around,[36] although the same child might be confused about an example of cause and effect from history.[37]

Analogies—Five-year-old children can make analogies between cut-up Playdoh and a cut-up apple.[38] Still, children might not be able to see the analogy between a medical problem and a military problem—an analogy that adults also have trouble applying.[39]

Metaphors—Nine-year-old school children do not take the statement, "The ocean roared," literally,[40] although they might take other metaphors, similes, or proverbs literally, especially with unfamiliar topics.

ADULTS

In general, researchers are finding that children's thinking is more competent than had been thought, but also that adults' thinking is less competent than had been thought.[41]

☞ For teachers, this means that students have many skills that we can build on to teach abstract concepts. For example, a student who understands that water and sun cause plants to grow can transfer the concept of cause and effect to how gases behave—increased heat causes increased pressure. However, the challenge is to help students transfer knowledge from one subject area to another. (See Fact Sheet 2: Making Connections for more information.)

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Helping Students Think In Unfamiliar Subject Areas

☞ There are different periods in the development of thinking when certain teaching strategies and ways of explaining things are more effective than others. You may have taught many students who can understand an idea if you give them a concrete example, but not if you give a dictionary definition. There are teaching strategies that can help students make the transition to using abstract thinking more often, especially in unfamiliar contexts.

☞ Demonstrating how to solve problems (not just explaining rules) can help students learn faster.[42] For example, after learning about plant cells and animal cells, ask students to look at some diagrams of cells and tell you which ones are plant and which are animal. Begin with an example and explain what features of the cells you are looking for and how you recognize them in the example. This may be particularly helpful when you are teaching students how to solve a problem using familiar skills (like deduction) in an unfamiliar topic (like plant biology).

☞ Robert Slavin suggests these four principles for helping students learn abstract thinking skills:[43]

1. Begin with familiar examples when you introduce a new abstract concept, then move on to less familiar examples.
2. Give students extra help when they need to do a lot of planning for an assignment (such as a research paper). Provide a checklist or pair up students who plan well with those who do not.
3. Ask students to restate new abstract concepts in their own words so they can understand what the concepts mean.
4. Do activities that require students to use abstract thinking like compare and contrast papers; debates; group projects that require planning; or comparing advertisements that make competing claims.

☞ Research on learning concepts shows that students learn best if they learn the concept in a familiar topic area first and then see the same concept applied in a variety of topic areas. For example, students learned about a cowboy term *minge*, which means "to gang up on." The best learning was with students who first heard four cowboy examples using the concept *minge* ("The three riders decided to *minge* (converge on) the cow."), and then heard several examples of the same concept in four other settings ("The band of sailors *minged* (angrily denounced) the captain and threatened a mutiny.") Students did not learn as well if they only heard familiar examples or only heard examples from other settings.[44]

☞ Here is one structured way to teach new concepts:[45]
Step 1. Give a definition and show a picture or a model (if possible). For example: Dejected—very sad because of something that happened, but still able to get on with life.
Step 2. Explain some similar concepts that are not the same, and explain the difference. For example: Sad—could be for a long time or a short time, for a reason or for no reason at all. Depressed—so sad for so long that a person cannot go about his or her normal life.
Step 3: Give examples of the concept. For example: He was dejected over losing his job until he got a new one—he was very sad because he needed the job, but his sadness only lasted a little while. She was dejected when Sam was not available for a date on Friday, but she brightened up when he called her on Saturday and asked her to go to the movies.
Step 4: Give non-examples and explain why they are not examples of the concept. For example:

She was sad that she had never gone to medical school—this is not a single event. He was so depressed about losing his job that he was admitted to the hospital—he was not still able to function.

Step 5: Ask students to sort choices into examples and non-examples and explain why they sorted the way they did.

Step 6: Ask students to come up with examples and non-examples and explain why they sorted the way they did.

Summary

1. Some thinking skills develop naturally in all normal people, without any schooling. These include language, short-term memory, and repeating things to remember them.
2. Many thinking skills develop from schooling. These include reading, sorting objects into categories, problem solving, understanding figurative language, and many abilities that underlie IQ, such as vocabulary and verbal analogies.
3. Even children have many thinking skills, which they will use on familiar topics.

What it means for teachers

Building On Existing Skills

🔑 Adult learners have a wide range of thinking skills in familiar areas. We can find out what our students' thinking skills are if we ask the right questions (see below).

🔑 We can use our students' thinking and problem-solving skills in familiar areas to build bridges to unfamiliar topics.

Teaching School-Acquired Thinking Skills

🔑 Teach for understanding, not just memorizing.[46] Ask "Why do you think . . . ?" at every opportunity. Why do you think the United States has a democratic government? Why do you think fish have gills? Why do you think the author used the word "promises" on this line of the poem? Why do you think plant cells and animal cells are different? Why do you think the GED asks this kind of question? Most textbooks (especially in history) do not explain why, but simply present facts.[47]

🔑 Use hands-on activities that show fundamental relations. For example, Karen Fuson uses paper strips with pictures of 10 pennies on each to teach students about adding "10's" and "1's."[48]

🔑 Identify the tasks involved in GED questions, and teach those skills. For example, teach how to rephrase the question in your own words (you need to know synonyms), the relationship between the questions and long passages, types of questions, and so on.[49]

🔑 Whatever thinking skills you want students to have, teach those skills directly and give students the opportunity to practice them. For example, if you want them to be able to infer unstated facts, they need to practice inferring unstated facts in class and get feedback on their performance.[50] You need to define what an inference is, give examples, and demonstrate making inferences, but that is not enough. Students also need to practice doing it themselves.

🔑 Teach information and skills together. For example, teach vocabulary words in context, not just from vocabulary lists or worksheets.[51]

Asking Questions That Reveal Skills

🔑 Use familiar subject areas when you want to find out the kind of thinking your students are able to do. For example, if you want to find out if your students can make inferences from literature, use an example from a familiar social setting (like a domestic scene or a soap opera).

🔑 Ask students what skills they feel they already have and test their ability to apply those skills. For example, if they say they read fast, give them timed reading tests and compare their reading speed to the speed they will need to pass the GED.

Helping Students Think In Unfamiliar Subject Areas

🔑 Some topics are hard to learn until other skills have been mastered. It is impossible to learn how to do math with fractions and decimals until you know how to do whole number math. It is hard to learn about other forms of government until you understand what government does and how your own government works. Pre-GED and GED textbooks are quite sensitive to the need to lay the groundwork for skills that will be taught later.

Lesson Ideas

✍ Look at the lesson ideas from the fact sheets in this book and choose one that pushes your students to use a strategy that they have but do not use fluently yet.

Writing

✍ Some writing exercises can make students' writing much more mature in a short time:

- sentence combining, where students practice making two short sentences into one, or
- sentence openers, where students are given possible beginnings for sentences on cards that they can choose from (such as "Nevertheless, . . ." or "On the other hand . . .).[52]

Teaching Abstract Ideas

✍ Build on ideas that students are sure of when you introduce a new abstract concept. For example, many students think that when you push down on a spring, the spring pushes back. But they believe that when you push down on a table, the table does **not** push back. David Brown suggests a "bridging" analogy—If you put the book on a spring, does the spring push back? If you put the book on a thin board over sawhorses, does the board push back? If you put the book on the table, does the table push back?[53]

✍ Ask questions such as "How is a camera like a tape recorder?" (they both make a record of an event, one as a picture and one as a sound recording) to get students to notice abstract properties.[54]

✍ Present many examples of similar problems and ask students to identify what the problems have in common.

NOTES

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[1] Slavin, R. (1997). *Educational psychology: Theory and practice* (5th ed.). Boston: Allyn and Bacon, p. 84.

[2] Keil, F.C. (1998). Cognitive science and the origins of thought and knowledge. In R.M. Lerner (Ed.), *Handbook of child psychology: Vol. 1. Theoretical models.* New York: John Wiley & Sons.

[3] Gelman, R., & Baillargeon, R. (1983). A review of some Piagetian concepts. In J.H. Flavell & E.M. Markman (Eds.), *Handbook of child psychology: Vol. III: Cognitive development.* New York: John Wiley & Sons, p. 187.

[4] Scribner, S. (1984). Studying working intelligence. In B. Rogoff & J. Lave (Eds.), *Everyday cognition: Its development in social context.* Cambridge, MA: Harvard University Press, p. 10.

[5] The distinction between content-independent and content-dependent development is made by Weinert, F.E., & Helmke, A. (1998). The neglected role of individual differences in theoretical models of cognitive development. *Learning and Instruction, 8* (4), 309-323.

[6] In fact, these skills represent values that are important to American culture and represent a cultural consensus about what it is most important for people to know.

[7] Bjorklund, D.F. (1995). *Children's thinking: Developmental function and individual differences.* Pacific Grove, CA: Brooks/Cole, p. 267.

[8] Rosser, R. (1994). *Cognitive development: Psychological and biological perspectives.* Boston: Allyn and Bacon, p. 283.

[9] This is a somewhat controversial point, although no one disagrees that memory places limits on children's development. Brown, A.L., Bransford, J.D., Ferrara, R.A., & Campione, J.C. (1983). Learning, remembering, and understanding. In J.H. Flavell & E.M. Markman (Eds.), *Handbook of child psychology: Vol. III. Cognitive development,* pp. 126-129, 141. New York: John Wiley & Sons, p. 102.

[10] Bjorklund, *Children's thinking,* p. 256.

[11] Friedman, W. (1990). Development: The child's discovery of time. Chapter 6. In *About time: Inventing the fourth dimension.* Cambridge, MA: MIT Press.

[12] Bjorklund, *Children's thinking,* p. 124.

[13] Kuhn, D. (1990). Education for thinking: What can psychology contribute? In M. Schwebel, C.A. Maher & N.S. Fagley (Eds.), *Promoting cognitive growth over the life span.* Hillsdale, NJ: Erlbaum, and Glick, J. (1975). Cognitive development in cross-cultural perspective. In F. Horowitz (Ed.), *Review of child development research: Vol. 4.* Chicago: University of Chicago Press, p. 633, 644.

[14] Lee, K., & Karmiloff-Smith, A. (1996). The development of external symbol systems: The child as notator. In R. R.Gelman & T.K-F. Au (Eds.), *Perceptual and cognitive development.* New York: Academic Press.

[15] Siegler, R. (1998). *Children's thinking* (3rd ed.). Upper Saddle River, NJ: Prentice Hall, p. 170, p. 301.

[16] Resnick, L.B. (1987). Constructing knowledge in school. In L.S. Liben (Ed.), *Development and learning: conflict or congruence.* Hillsdale, NJ: Erlbaum.

[17] Bjorklund, *Children's thinking,* p. 219.

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[18] Siegler, *Children's thinking*, p. 259 and Bjorklund, *Children's thinking*, p. 237, 245.

[19] Bjorklund, *Children's thinking*, p. 455-56.

[20] Siegler, *Children's thinking*, p. 166.

[21] Torff, B., & Sternberg, R.J. (1998). Changing mind, changing world: Practical intelligence and tacit knowledge in adult learning. In M. C. Smith & T. Pourchot, (Eds.), *Adult learning and development: Perspectives from educational psychology*. Mahwah, NJ: Erlbaum, p. 114.

[22] Kuhn, D., Amsel, M., & O'Loughlin, E. (1988). *The development of scientific thinking skills*. New York: Academic Press.

[23] Presumably because of years of thinking about one's own thinking. Schraw, G. (1998). On the Development of Adult Metacognition. In M. C. Smith & T. Pourchot, (Eds.), *Adult learning and development: Perspectives from educational psychology*. Mahwah, NJ: Erlbaum.

[24] Siegler, *Children's thinking*, p. 200.

[25] Kuhn, D. (1995). Introduction to special issue on learning and development. *Human Development, 38* (6), 293-294; Brown, A.L., & Reeve, R.L. (1987). Bandwidths of Competence: The Role of Supportive Contexts in Learning and Development. In L.S. Liben (Ed.), *Development and learning: conflict or congruence*. Hillsdale, NJ: Erlbaum; and Schwebel, M., Maher, C.A., & Fagley, N.S. (1990). Introduction: The social role in promoting cognitive growth over the life span. In M. Schwebel, C.A. Maher & N.S. Fagley (Eds.), *Promoting cognitive growth over the life span*. Hillsdale NJ: Erlbaum.

[26] Gelman, S.A. (1996). Concepts and theories. In R. Gelman & T.K-F. Au (Eds.), *Perceptual and cognitive development*. New York: Academic Press.

[27] Smith, L.B., & Katz, D.B. (1996). Activity-Dependent Processes in Perceptual and Cognitive Development. In R. Gelman & T.K-F. Au (Eds.), *Perceptual and cognitive development*. New York: Academic Press, and Gelman & Baillargeon, A review of some Piagetian concepts. Rogoff et al. assert that, "The social system in which the child is embedded thus channels cognitive development," Lave, J. (1984). Introduction: Thinking and learning in social context. In B. Rogoff & J. Lave (Eds.), *Everyday cognition: Its development in social context*. Cambridge, MA: Harvard University Press, p. 4.

[28] Brown, Bransford, Ferrara & Campione, Learning, remembering, and understanding, p.88. These findings are taken as evidence of problems with Piaget's theory, at least in the form of rigid stages that he defended. In addition, I would argue that the development of thinking in low-literate adults is also evidence of problems with Piaget's model, which seems to be based on the development of thinking due to time, not due to certain opportunities to think.

[29] Gelman & Baillargeon, A review of some Piagetian concepts, p. 172.

[30] Siegler, *Children's thinking*, p. 269

[31] Siegler, *Children's thinking*, p. 273.

[32] Keil, F.C. (1989). *Concepts, kinds, and cognitive development*. Cambridge, MA: The MIT Press, p. ix. Susan Carey argues that children's concepts do not mean the same thing as adult concepts. For example, when children say "baby" they mean a younger, helpless version of an animal that needs an adult to do things for it. Therefore, worms cannot have babies (any more than rocks can have babies) because worms can do so little that young worms cannot possibly be able to do less than adult worms. Carey, S. (1988). Conceptual differences between children and adults. *Mind & Language, 3* (3), 167-181 and Carey, S. (1991). Knowledge acquisition: Enrichment or conceptual change? In S. Carey & R. Gelman (Eds.), *The epigenesis of mind: Essays on biology and cognition*. Hillsdale, NJ: Erlbaum. Elizabeth Spelke disagrees with this view of concepts and believes that reasoning develops gradually and there is never a radical change in reasoning. Spelke, E.S. (1991). Physical knowledge in infancy. In S. Carey & R. Gelman (Eds.), *The epigenesis of mind: Essays on biology and cognition*. Hillsdale, NJ: Erlbaum.

[33] Carey, S. (1985). Introduction. *Conceptual change in childhood*. Cambridge, MA: MIT Press.

[34] Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception, *Cognition, 13*, 103-28.

[35] Wellman, H.M., & Gelman, S.A. (1992). Cognitive development: Foundational theories of core domains. *Annual Review of Psychology, 43*, 337-75.

[36] Gelman & Baillargeon, A review of some Piagetian concepts.

[37] Annette Karmiloff-Smith argues that cause-and-effect is programmed into the brain from birth, Karmiloff-Smith, A. (1991). Beyond Modularity: Innate Constraints and Developmental Change. In S. Carey & R. Gelman (Eds.), *The epigenesis of mind: Essays on biology and cognition*. Hillsdale, NJ: Erlbaum.

[38] Wellman & Gelman, Cognitive development: Foundational theories of core domains.

[39] Gick, M.L., & Holyoak, K.J. (1983). Schema induction and analogical transfer. *Cognitive Psychology, 15*, 1-38.

[40] Rosser, *Cognitive development*, p. 251.

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[41] Kuhn, D. (1990). Education for thinking: What can psychology contribute? In M. Schwebel, C.A. Maher & N.S. Fagley (Eds.), *Promoting cognitive growth over the life span*. Hillsdale NJ: Erlbaum and Siegler, *Children's thinking*, p. 326-30.

[42] Mayer, R.E. (1992). *Thinking, problem solving, cognition* (2nd ed.). New York: W.H. Freeman, p. 439-452.

[43] Slavin, *Educational psychology*, pp. 98-99.

[44] Nitsch, K.E. (1977). Structuring decontextualized forms of knowledge. Unpublished doctoral dissertation, Vanderbilt University, cited in Brown, Bransford, Ferrara & Campione, Learning, remembering, and understanding, p. 105. This is similar to the finding in Gick & Holyoak, Schema induction and analogical transfer, that people transfer better when they get multiple dissimilar analogies than when they get one well-practiced analogy and a hint.

[45] Graves, M.F., Juel, C., & Graves, B.B. (1998). *Teaching reading in the 21st Century*. Boston: Allyn and Bacon, pp. 195-196. This method is called the Frayer method, Frayer, D.A., Frederick, W.D., & Klausmeier, H. J. (1972). Levels of concept mastery: Implications for instruction. *Educational Technology, 12*, 23-29.

[46] Resnick, L.B. (1987). Constructing knowledge in school. In L.S. Liben (Ed.), *Development and learning: conflict or congruence*. Hillsdale, NJ: Erlbaum and G. Halford, *Mental Models*. Hillsdale, NJ: Erlbaum, 1993.

[47] McKeown, M.G., & Beck, I.L. (1990). The assessment and characterization of young learners' knowledge of a topic in history. *American Educational Research Journal, 27*, 688-726.

[48] Demonstration at the National Academy of Sciences Conference on Learning Research and Educational Practice, December 18, 1998, Washington, DC and Siegler, *Children's thinking*, p. 96.

[49] Brown, Bransford, Ferrara & Campione, Learning, remembering, and understanding, p. 140.

[50] Byrnes, J. (1996). *Cognitive development and learning in instructional contexts*, Boston: Allyn and Bacon, p. 128.

[51] Siegler, *Children's thinking*, p. 166.

[52] Siegler, *Children's thinking*, p. 312.

[53] Brown, D.E. (1992). Using examples and analogies to remediate misconceptions in physics: Factors influencing conceptual change. *Journal of Research in Science Teaching, 29*, 17-34.

[54] Siegler, *Children's thinking*, p. 265.

Fact Sheet 10: How Thinking Develops, Part 2—Changes in Strategies

Principle: Development Means Changes in Strategies

> "In a study of Kpelle farmers from Liberia, adults consistently sorted objects into functional groups (for example, knife and orange, potato and hoe) [as Western children do], rather than in terms of conceptual categories (for example, potato and orange, hoe and knife) [as Western adults do]. . . When asked how a fool would do the task, the farmers classified the objects into neat conceptually based piles, exactly as Westerners do."—From research by Joseph Glick[1]

Questions for teacher reflection

- Think about a time in your own K-12 education when you remember struggling with a new idea. What made that idea difficult for you?
- Are there subjects where you feel you are a better thinker than others? (For example, do you think better about current events than about economics?)
- What is your model of how thinking develops? Do you think it just happens? Do you think it is learned? What kinds of learning experiences help thinking develop?

What we know

Development Myths And Findings

Myth: All third graders are illogical, all twelfth graders are logical.
Findings

☞ A common-sense, but inaccurate, way to look at development is to consider what thinking is like at different ages, such as "All third graders are illogical, all twelfth graders are logical." or "All fifth graders are concrete, all tenth graders are abstract." Unfortunately, evidence does not support this model of rigid, well-defined stages in thinking.[2] Human beings are much more complicated than this. Third graders can be very logical in some situations and twelfth graders illogical in some situations. Fifth graders sometimes think abstractly, tenth graders are sometimes stuck in concrete ways of thinking.[3] One person may think very concretely in math but abstractly in grammar at the same time.[4]

☞ Of course there are major differences between children and adults, but thinking does not seem to develop evenly across subjects, even in normal children.[5] Thinking does not seem to develop in absolute stages, where a person goes from never being able to think in a certain way, to always thinking in a better way.[6] Instead, there seem to be characteristic patterns of thinking that become more common in a typical order, which develop unevenly in different subject areas,[7] and which are based on certain thinking experiences[8] over a person's lifetime.[9] "Development occurs at multiple levels and has many faces," according to Edith Ackermann.[10]

Myth: Thinking goes from entirely concrete to entirely abstract.
Findings

☞ Because less experienced thinkers have trouble with almost any abstract explanations and more experienced thinkers are often able to understand many abstract explanations,[11] one way of thinking about development is to look at patterns of thinking strategies. How often do fifth graders and tenth graders use concrete or abstract thinking in each subject area? Although fifth graders have trouble thinking abstractly, does that define who they are? Robert Siegler has summarized four things that develop over time and with experience:

1. basic processes (like distinguishing sounds, learning to speak, or memory development),
2. self-awareness of oneself as a thinker and learner,
3. strategies (like counting up for adding or sounding out for reading), and
4. content knowledge (facts and ways of thinking in math, history, government, and so on).[12]

ADULTS

Of these four areas, **strategies** and **content knowledge** are most important for teachers of adults, because they do not develop naturally. Strategies and content knowledge can both be effectively taught (and in fact should be taught together).

☞ Strategy use influences how people learn and understand content knowledge; growing content knowledge changes strategy use,[13] so both are important for development. Fact Sheets 1, 3, 4, and 12 cover growth in content knowledge in detail. This fact sheet focuses on changing strategies.

Myth: Beginners have only one strategy, experienced thinkers use lots of strategies.
Findings:

☞ Many of the differences between beginning thinkers and more experienced thinkers show up in the strategies they use.[14] Beginning thinkers have a few strategies, which they do not use effectively. Intermediate thinkers have many strategies, but still do not use them in the most effective way. Experienced thinkers have the most strategies and use them effectively. Reading strategies are a good example of this process.

☞ Reading strategies include recognizing a whole word; asking a family member, teacher, or friend; sounding out the whole word; sounding out the beginning of the word and recognizing the rest of the word; inferring the meaning of the word from context; using a dictionary; guessing; and giving up.

☞ **Beginning readers** can recognize a few words, ask for help with many words, and can sometimes sound out words. They do not always know when to use which strategy, and the strategies they use do not always work (for example, they may mis-pronounce a word when sounding it out). Beginning readers still use more than one strategy—they are not just stuck with one poor strategy.

☞ **Intermediate readers** have many more strategies. In addition to beginners' strategies, they also know they can sound out the beginning of the word and recognize the rest of the word, infer from context, or use a dictionary. But, again, they do not always know when to use which strategy (when to sound out the beginning of the word and infer the meaning from context use and when to use a dictionary). And the strategies they use do not always work (for example, they may not recognize that a friend's definition does not fit the meaning of the sentence). Intermediate readers use a large number of strategies, but do not use them to full effect.

☞ **Experienced readers** have the most strategies, and they use them effectively. That is, they use a few very effective strategies most of the time, but have other strategies available when they need them. For example, you probably recognize most words from sight, but when you come across a new word, you know when to sound out a word, when to look for a root word, when to look the word up, and so on.

☞ The chart below shows how often each strategy might be used for four hypothetical readers at different levels of development.

recognize = recognizing words by sight
ASK = asking someone what the word is
sound = sounding out the word from the letters
context = guessing the word from context
DICTIONARY = looking up the word

recognize	**recognize**	**recognize**	**Recognize**
recognize	**recognize**	**recognize**	**Recognize**
ASK	ASK	ASK	**Recognize**
ASK	ASK	***sound***	**Recognize**
ASK	***sound***	***sound***	***sound (e.g.,***
ASK	***sound***	sound/recognize	***technical words)***
ASK	***sound***	sound/recognize	sound/recognize
sound	context	sound/recognize	**sound/context**
context	context	DICTIONARY	DICTIONARY
Beginning reader Appears to just ask	Beg./Int. reader Appears to just sound out	Intermediate reader Appears to sound out & recognize	Experienced reader Appears to just recognize

Old Strategies Never Die

☞ Notice that as readers develop, they do not get rid of old strategies but instead change how often they use different strategies. Also notice that intermediate readers use the widest variety of strategies, but this is because they do not know when to use each strategy most effectively. Finally, notice that inferring meaning from context and sounding out[15] are not the most effective strategies, although they are both needed some of the time at different levels.

☞ This pattern of beginning, intermediate, and advanced strategy use is true across many different subject areas (math and reading have been studied a lot, but also spelling, writing, grammar, syntax, scientific experimentation, and even infants' methods of getting down a steep hill).[16] So an important role for teachers is to help students learn both more strategies and when each strategy is most effective.

☞ The emerging consensus is that thinking develops in stage-like sequences, but that there are no absolute stages at specific ages.[17] Nonetheless, there are some characteristics of less experienced thinkers that are so common they are worth listing:[18]

In unfamiliar areas or where they do not feel competent, less experienced thinkers **tend to**:[19]	In familiar areas where they also feel competent, less experienced thinkers **tend to** be able to:
• Need concrete examples • Understand words literally[20] • Learn by rote without understanding[21] • Have trouble reasoning about opinions they disagree with[22] • Think good reading means pronouncing words well	• Understand abstract explanations[23] • Understand metaphors, similes, proverbs, and other figurative language • Learn by understanding fundamental relationships • Reason well about opinions, even ones they disagree with[24] • Think good reading means getting information from a text[25]

ADULTS

Most adults, even those with a college education, have trouble with the items in the right-hand column above in some settings. A large body of research on thinking errors among adults shows how often people use faulty reasoning on unfamiliar or emotionally-charged topics.[26]

How Does Development Happen?

☞ Development happens when adults get better strategies, use them better, and increase their content knowledge.[27] Early in development, people have few strategies and do not use them effectively on the little content knowledge they have. As people develop, they learn more strategies and use them better and on a wider range of content knowledge. Most of these strategies are learned in school, they do not develop on their own. Surprisingly enough, strategy change does not seem to happen because people feel that old strategies are not working.[28] Rather, it seems to happen when people are challenged with difficult problems where familiar strategies are too time-consuming.[29] The less familiar strategies then have be used so often that they also become automatic.

☞ For example, most children under six count from one when they are adding (for 4 + 2 they count "1,2,3,4,5,6"). Later they discover that they can just count up from the larger number (so for 4 + 2 they count "4," then "5,6"). They may know the better strategy for quite a while before they use it often, until they get problems (like 2 + 24) where counting from one takes a long time. Then they begin to use the better strategy on many more problems. Eventually, they memorize all of the one-digit additions (we hope!) and do not need to count any more.[30] (See Fact Sheet 8: Long-Term Memory and Learning for more information about strategies that become "second nature.")

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☞At any given time, some strategies are more practiced and more effective than others for the range of problems that one person faces in a particular subject. To return to the reading example, a beginning reader has a little practice with sounding out and a lot of practice with asking people "What is this word?" The sounding out strategy is a little practiced and a little effective. The asking strategy is a lot practiced and very effective, at least until a teacher says, "I want you to figure it out for yourself." The practiced strategies are the most familiar and are the ones the person is most comfortable with. Other strategies are not as familiar and the person is less comfortable with them and confident in them. This explains why, for example, students who can sound out words sometimes do not.[31] After all, it is painful to switch from a strategy that you are good at to one that you are not good at and to "go backwards in order to go forwards." So beginning adult readers' strategies may not be the ones we would use, but they work more comfortably for the reader than the other strategies they have.[32]

☞As teachers, we can take advantage of this general pattern of strategy development when we teach adult learners. First, identify the range of strategies your students use by giving them familiar problems. Then give them much more difficult problems that make it worthwhile for them to use less familiar strategies.[33] We already do this with dictionaries. When students come across a word they cannot sound out, we often tell them to look it up in the dictionary. With enough practice, the dictionary eventually becomes easier to use, and dictionary use becomes a more effective strategy.

☞One key to changing strategies is that both children and adults need to see that a) they performed better and b) it was the **strategy** (and not just luck or working harder) that made the difference.[34] (See Fact Sheet 4: Thinking About Thinking for guidelines on teaching new strategies to students.)

☞Some other characteristics of development are:

- Skills such as speaking, reading, and drawing conclusions become automatic as they are practiced over and over again. This frees up attention so people can notice more aspects of the situation (for example, paying attention to the plot of a story instead of needing to spend all of your attention on decoding the words).

ADULTS

- The pattern of first trying to give the right answer and only later trying to understand why a strategy works is common with children, and, in my experience, with adults too.[35]
- There is a set of common misconceptions among children that probably persists in many adult students. These include misunderstandings of the shape of the Earth, how objects move when they are thrown forward and dropped at the same time, and applying whole-number principles to decimals (thinking that .268 must be bigger than .45 because 268 is bigger than 45).[36]
- More active, involved children are exposed to more varied environments, which leads to more developed thinking.[37] Level of involvement affects adult literacy students too, since teachers often respond with more attention to more engaged, involved students.

- Background knowledge and exposure to a wide variety of experiences are critical for development. For example, a three year old may think that only women use vacuum cleaners because she has only seen women use them. An older child has seen many more people vacuuming and understands that the important thing about vacuum cleaners is that they clean, not that women use them.[38] It is the varied experiences (and often parents' feedback) that lead the child to see the important aspects of the situation.[39] Some of our students' limited reasoning has to do with their limited background knowledge.[40] (See Fact Sheet 1: Literature is not Science for more about the role of background knowledge.)

Summary

1. Thinking does not generally develop from concrete to abstract, but from more familiar to less familiar.
2. Development includes basic processes (speech), self-awareness of thinking, strategies, and content knowledge.
3. Beginning thinkers have few strategies and do not know when to use them. Advanced thinkers have many strategies and know when each will be most effective.
4. Advanced thinkers do not get rid of old strategies, but use them less.
5. Development happens when situations demand the use of more sophisticated strategies.
6. Some students do not use the strategies they have because they are not comfortable with the new strategies.
7. Some of our students' limited reasoning has to do with their lack of background knowledge.

What it means for teachers

Learning To Think

"The only effective way to teach people to think is to engage them in thinking."—Deanna Kuhn[41]

The best ways for students to learn to think are:

1) Watching teachers and others solve problems out loud and explaining their thinking process and
2) Practicing thinking and getting feedback on it.[42]

Students need to practice the specific skills you want them to have (See Fact Sheet 9: How Thinking Develops, Part 1 for more information).

What Development Is

Remember that students who are not experienced thinkers **about school topics** still have adult experiences, interests, and lives. Just because their deductive powers are not "school-like," does not mean that they are not adults.

- Based on research about the development of thinking, we should be hopeful that adult students' thinking can mature, given enough practice. Just because their thinking did not develop as children does not mean that it cannot develop now.

- Recognize that students' thinking abilities will be very uneven from topic to topic because of uneven practice and background knowledge.

Changing Student Strategies And Increasing Content Knowledge

- See Fact Sheet 4: Thinking About Thinking for guidelines on teaching new strategies to students.

- Challenge students with difficult problems that require them to use better strategies which they already have but are not comfortable with yet. Create an atmosphere in which students "feel successful and competent, but also challenged."[43]

- Support students as they struggle with less-practiced strategies and remind them that part of learning is "going back so that you can go forward." Expect students to switch back and forth between using more effective new strategies and more comfortable old strategies.

- Set high expectations for adults to learn the content you are teaching. Use tests and rewards for good performance to motivate students to study and learn.

- Students need to see problems over and over again before they can abstract the principles of the problem.[44] For example, they need to capitalize over and over again before they can abstract the rule, "capitalize the names of people, places, times, and product names."

- Think about covering less material, but in more depth. Stress principles that are major themes in a subject, like interest groups in history or full electron shells in chemistry. Give students a lot of examples, practice, application, and discussion to be sure they really understand.[45]

- After you present a theory (such as plate tectonics), ask students, "Do you think this could be true?"

Lesson Ideas

Categorizing

- After you finish a unit, give students a set of cards with vocabulary words and ask them to sort them into categories.[46] For example, after a unit on the body, have students sort organs into different systems. Be sure to ask students to explain why they grouped things the way they did.

- Create exercises with three like objects and one unlike object based on the subject you are studying. Ask students to explain which item does not belong and why. For example, for a unit on the Civil War, use a gun, railroad, factory, and car and ask students to explain which one does not belong and why.

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✍ Play "20 Questions" to help students learn to use category words ("Is it a mammal?").

What If . . .

✍ Ask students to imagine that things work differently, and have them try to explain what they think would happen. What if there were no gravity? What if plants could walk? What if Germany had won World War II?[47]

✍ Create a Model United Nations, mock Congress, or other role play where students have to take a position on an issue and defend it. Each team has to research facts about their country or party (or have one teacher serve as a resource person for each team).[48]

Taking Sides

✍ Split students up into teams and have a debate. Each side must defend their opinion with facts that the students research (or have one teacher serve as a resource person for each team).

✍ Have students read opposing viewpoints about a topic and discuss the different points of view and evidence. You could use the day's editorials from two newspapers with opposing political views or from two writers with opposing views.

Noticing Patterns

✍ Present four or more examples of a type of problem for students to work on. After discussing each of the problems, ask students what the problems have in common. For example, have students look up two words that begin with "anti-" and two words that begin with "extra-" and ask students what the problems have in common (prefixes and word meanings).[49]

✍ Give students hands-on experiments that show patterns and ask them to make a graph of the results. Be sure the experiment is related to the reading assignment. For example, compare heartbeat and level of exercise (walking across the room vs. up and down stairs) or how high a ball bounces after it is dropped (a few inches vs. a few feet).

Theories And Evidence

✍ Ask students to come up with a hypothesis that they can test and then do an experiment or research.[50] Both science and social studies topics will work, but students should be very familiar with the topic before they do an experiment. The best ideas to test may be "self-evident" ones, like the theory that heavy things fall faster than light things, or that all White Americans are rich and all Black Americans are poor.[51]

NOTES

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[1] The quote is from Bjorklund, D.F. (1995). *Children's thinking: Developmental function and individual differences.* Pacific Grove, CA: Brooks/Cole, p. 444. Research done by Glick, J. (1975). Cognitive development

in cross-cultural perspective. In F. Horowitz (Ed.), *Review of child development research: Vol. 4.* Chicago: University of Chicago Press.

[2] Gelman, R., & Baillargeon, R. (1983). A review of some Piagetian concepts. In J.H. Flavell & E.M. Markman (Eds.), *Handbook of child psychology: Vol. III. Cognitive development.* New York: John Wiley & Sons, p. 167 and Gardner, H. (1983). *Frames of mind.* New York: Basic Books, p. 315.

[3] Gardner, H. (1986). Notes on cognitive development: Recent trends, new directions. In S.L. Friedman, K.A. Klivington & R.W. Peterson (Eds.), *The brain, cognition, and education.* New York: Academic Press, and Flavell, J.H. (1981). On cognitive development. *Child Development, 53,* 1-10.

[4] Keil, F.C. (1998). Cognitive science and the origins of thought and knowledge. In R.M. Lerner (Ed.), *Handbook of child psychology: Vol. I. Theoretical models.* New York: John Wiley & Sons and Bjorklund, *Children's thinking,* p. 455.

[5] Keil, F.C. (1989). *Concepts, kinds, and cognitive development.* Cambridge, MA: The MIT Press.

[6] There are many competing models of development, including Piagetian--Jean Piaget (especially the works from 1946-1971) [thinking develops from concrete to abstract]; Neo-Piagetian--Robbie Case (1992), J. Bruner, et al. (1966) [from perceptual to conceptual], Robert Sternberg (1985), Kurt Fischer (Fischer & Bedell, 1991), Annette Karmiloff-Smith (1992), Charles Brainerd and Valerie Reyna (1993), Frank Keil (1989), Susan Carey (1985); Constructivist—Vygotsky (1962) [thematic to taxonomic]; Connectionist--B. MacWhinney (MacWhinney, et al., 1989); Quinean (1977) [similarity to theories]; in addition to Siegler's strategy change model. S. Strauss summarizes some competing theories in Strauss, S. (1993). Theories of learning and development for academics and educators. *Educational Psychologist, 28* (3), 191-203.

[7] Kuhn, D. (1990). Education for thinking: What can psychology contribute? In M. Schwebel, C.A. Maher & N.S. Fagley (Eds.), *Promoting cognitive growth over the life span.* Hillsdale, NJ: Erlbaum, p. 42.

[8] Halford, G. (1993). *Mental models.* Hillsdale, NJ: Erlbaum, p. 275.

[9] This would be described as an information-processing model. Frank Keil argues for a "characteristic [features] to defining [abstract]" shift, Keil, F.C. (1991). The emergence of theoretical beliefs as constraints on concepts. In S. Carey & R. Gelman (Eds.), *The epigenesis of mind: Essays on biology and cognition.* Hillsdale, NJ: Erlbaum.

[10] Ackermann, E.K. (1998). New trends in cognitive development: Theoretical and empirical contributions. *Learning and Instruction, 8* (4), 375-385.

[11] Some researchers argue that this is about preference, not ability. Glick, J. (1975). Cognitive development in cross-cultural perspective. In F. Horowitz (Ed.), *Review of child development research: Vol. 4.* Chicago: University of Chicago Press, p. 626 and Gelman & Baillargeon, A review of some Piagetian concepts, p. 195. Ironically, in some situations children do better with an abstract map than with a concrete model, because they find the model itself interesting and are distracted by it. Lee, K., & Karmiloff-Smith, A. (1996). The development of external symbol systems: The child as notator. In R. Gelman & T.K-F. Au (Eds.), *Perceptual and cognitive development.* New York: Academic Press.

[12] Siegler, R. (1998). *Children's thinking* (3rd ed.). Upper Saddle River, NJ: Prentice Hall, p. 320, 332-35.

[13] Peverly, S.T. (1991). Problems with the knowledge-based explanation of memory and development. *Review of Educational Research, 61* (1), 71-93.

[14] Brown, A.L., Bransford, J.D., Ferrara, R.A., & Campione, J.C. (1983). Learning, remembering, and understanding. In J.H. Flavell & E.M. Markman (Eds.), *Handbook of child psychology: Vol. III. Cognitive development,* p. 78.

[15] Byrnes, J. (1996). *Cognitive development and learning in instructional contexts,* Boston: Allyn and Bacon, p. 98, 101 and Bjorklund, *Children's thinking,* p. 343.

[16] Siegler, R.S. (1996). The adaptivity of multiplicity. Chapter 5 in *Emerging minds: The process of change in children's thinking.* New York: Oxford University Press.

[17] Brown, Bransford, Ferrara & Campione, Learning, remembering, and understanding, p. 84, 90, and Flavell, On cognitive development, p. 4.

[18] James Byrnes notes that "The poor performance of younger students [on social studies learning] may have more to do with lack of experience than with a basic inability to learn the material." *Cognitive development,* p. 216. These categories roughly correspond to Piaget's "concrete operational" stage, but are not as absolute as in Piaget's theory. For example, some less experienced thinkers will be able to think abstractly on some thinking tasks (especially in familiar content areas where they feel confident). At the same time, the same person on a different thinking task may think in an egocentric way or be unable to reason about more than one dimension of a problem, which in Piaget's theory are characteristic of an earlier developmental stage. Piaget, J. (1970). Piaget's theory. In P. Mussen (Ed.), *Carmichael's manual of child psychology: Vol. 1.* New York: John Wiley.

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[19] Howard Gardner points out that "Under certain circumstances, adults must pass through stages of learning paralleling those realized by the young child." Gardner, *Frames of mind*, p. 315.

[20] Doak, C.C. , Doak, L.G., & Root, J.H. (1995). *Teaching patients with low literacy skills* (2nd ed.). Philadelphia: Lippincott.

[21] This is probably partly an artifact of how teaching is done—that is, when teachers do not teach for understanding, students come to believe that the point of learning is not to understand, but to memorize.

[22] Siegler, *Children's thinking*, p. 315

[23] Byrnes, *Cognitive development*, p. 197.

[24] Slavin, R. (1997). *Educational psychology: Theory and practice* (5th ed.). Boston: Allyn and Bacon, p. 98.

[25] Byrnes, *Cognitive development*, p. 123.

[26] Reisberg, D. (1997). Judgement and Reasoning. Chapters 11 and 12. In D. Riesberg, *Cognition: Exploring the science of the mind*. New York: W.W. Norton and Byrnes, *Cognitive development*, p. 186-87.

[27] There is a lively debate about the difference between development and learning. If a thinking skill can be learned, some argue that it is not part of development. However, others argue that there are common patterns of change in thinking over time (for example, from more concrete to more abstract) and that these patterns make up development. See the special issues of *Educational Psychologist, 28* (3), 1993; *Human Development, 38,* November-December 1995; and *Learning and Instruction, 8* (4), 1998 and Granott, N. We learn, therefore we develop: Learning versus development—or developing learning? In M. C. Smith & T. Pourchot, (Eds.), *Adult learning and development: Perspectives from educational psychology*. Mahwah, NJ: Erlbaum.

[28] Resnick, L.B. (1987). Constructing knowledge in school. In L.S. Liben (Ed.), *Development and learning: conflict or congruence*. Hillsdale, NJ: Erlbaum.

[29] Frederiksen, J.R., & White, B.Y. (1988). Intelligent testing within an intelligent tutoring system. *Machine-Mediated Learning, 2*, 351-372, p. 361.

[30] Siegler, *Emerging minds*, p. 186.

[31] Brown, Bransford, Ferrara & Campione, Learning, remembering, and understanding, p. 92-94.

[32] Siegler, *Emerging minds*, Chapter 5, The adaptivity of multiplicity.

[33] Educational psychologist Lev Vygotsky calls this area of more difficult problems that a person is capable of solving the Zone of Proximal Development, Vygotsky, L. (1978). *Mind in society*. Cambridge, MA: Harvard University Press, pp. 84-91.

[34] Kuhn, Education for thinking, p. 42.

[35] Siegler, *Children's thinking*, p. 270 and 335.

[36] Siegler, *Children's thinking*, p. 348.

[37] Bjorklund, in *Children's thinking*, p. 6 uses the example of an infant who will not be confined to a playpen, and gets more experiences (of touching, hearing, smelling, etc.) simply within his or her own home than a child who is willing to stay in the playpen.

[38] This example is from Byrnes, *Cognitive development*, p. 22.

[39] Bjorklund, *Children's thinking*, p. 201.

[40] Byrnes, *Cognitive development*, p. 221.

[41] Kuhn, Education for thinking, p. 39.

[42] Byrnes, *Cognitive development*, p. 79.

[43] Byrnes, *Cognitive development*, p. 251.

[44] Byrnes, *Cognitive development*, p. 62.

[45] Byrnes, *Cognitive development*, p. 222.

[46] Byrnes, *Cognitive development*, p. 80.

[47] Byrnes, *Cognitive development*, p. 224.

[48] Byrnes, *Cognitive development*, p. 224.

[49] Byrnes, *Cognitive development*, p. 79.

[50] Byrnes, *Cognitive development*, p. 201.

[51] Howard Gardner makes a strong case for confronting students' misconceptions as a teaching method in Gardner, H. (1991). *The unschooled mind: How children think and how schools should teach*. New York: Basic Books.

Fact Sheet 11: How Thinking Develops, Part 3—Experience Makes Some Difference for Adults

Principle: Experience Makes Learning Different for Adults

> "We compared shoppers' arithmetic in the supermarket with their performance on an extensive paper-and-pencil arithmetic test . . . Their scores averaged 59% on the arithmetic test, compared with a startling 98%—virtually error free—arithmetic in the supermarket."—Jean Lave, Educational Anthropologist[1]

Questions for teacher reflection

- What have you learned since you left school?
- What do you think your students have learned since they left school?
- What have you forgotten since you left school?
- What do you think your students have forgotten since they left school?
- Do you think it is easier or harder to learn as an adult than as a child?

What we know

Differences Between Children And Adults

☞ Imagine an eight year old who reads at a 3rd grade level and a 35 year old who also reads at a 3rd grade level both trying to understand an easy-to-read version of Edgar Allen Poe's "The Telltale Heart." Both people will have trouble decoding the words off the page, have small vocabularies, and probably read quite literally. But the eight year old:

- has a limited working-memory capacity which makes it hard to keep the story straight;
- is interested in cartoons on TV, toys, friendships and other appropriate child-like pastimes;
- has trouble telling reality from fantasy in some situations;
- has not had adult experiences of anger, guilt, and so on that the story is concerned with; and
- has not had experiences with police and the legal system.

The 35 year old has some significant advantages over the child. She:[2]

- has a fully-developed working memory that helps her keep the story straight;
- has adult interests which may include current events and crime, neighborhood dynamics, and social conditions;
- clearly distinguishes reality from fantasy in almost all situations;
- has had adult experiences of anger and guilt, as well as social relationships that give her a context for the story;
- has learned to recognize and solve many problems in her life (how to get to work on the bus, how to eat on a small budget, what to say to her supervisor, and so on); and
- has had experiences with police and the legal system, either in her neighborhood, or among people she knows.[3]

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ADULTS
Even though adults have been alive longer than children, they may have had "one year repeated forty times" rather than 40 years' experience.[4] Despite their family, job, and other adult experiences, many adult literacy students have small vocabularies (about 15% larger than a 5th grader's vocabulary).[5] Children's vocabularies after about 5th grade grow mostly from what they read, not from hearing new words,[6] but adult literacy students have never read much. Basically, adult literacy students use the same small spoken vocabulary as when they were 11 or 12.

ADULTS
There are a few ways that adult students' thinking is different from children's thinking even at the same level of educational skills. These differences in memory, interests, life experience, and background knowledge[7] (including social relationships and multiple points of view) give adult literacy students some basis for understanding more sophisticated reading materials than children can.[8]

For example, having more background knowledge improves how much and how fast you can remember, how much and how fast you can learn, how well you can organize facts, and it improves reading comprehension (including metaphors) and ability to do math word problems, among other skills.[9]

ADULTS
When low-literate adults read about unfamiliar topics, they perform worse than children who are reading at the same reading level.[10] In a study where adults and children read about Roland and Charlemagne, 5th grade children had better comprehension than adults who tested at the 8th grade level.

☞ Limits on working memory have a major effect on young children's learning, but not on that of normal adults.[11] In fact, many parts of children's thinking development simply reflect a growing working memory. For example, a young child will have trouble solving a math word problem because she cannot hold the numbers and the story in her mind at the same time.
A large part of development is making better use of the memory capacity and processing speed you do have.[12] Adult learners with normal memories do not face these limits; their working memory is already as large as it will ever be. Young children may seem to learn quickly because their memories are improving at the same time that they are learning new skills in school.[13]

ADULTS
Students who feel they "can't learn" as adults may be comparing their experience of learning as adults with this feeling of learning rapidly as children.

Improved Skills

One theory about the mind is that some thinking skills (such as short-term memory)[14] stay the same from young adulthood on, while some skills (such as cultural knowledge and vocabulary) can improve with age and experience.[15] The skills that can improve over time are more relevant to practical, real-life problems than the skills that do not improve.[16] Adults learn practical skills on the job and in their lives, but they also can and do learn school subjects, as our experience shows.

☞ Everyday life skills that develop with practice, such as grocery store math, may not show up in school subjects.[17] For example, studies of "bookies" at racetracks show that they have a very sophisticated, implicit understanding of statistics, but they do not score well on pencil-and-paper statistics tests.[18] Their statistics knowledge seems to be attached to the racetrack. In fact, some researchers feel that all knowledge is attached to particular situations.[19]

ADULTS

Adults generally feel they have become wiser during their adult years.[20] This practical learning tends to be "how-to" skills, such as how to figure out which bus to take or how to communicate effectively with a supervisor.[21] This kind of learning peaks between age 40 and 59, unlike school-type problem solving, which peaks in the mid-30s.[22] Practical learning includes less fact learning than is typical of school subjects; practical skills also depend on a small knowledge base, unlike school subjects.[23] The workplace is an important place where adults develop reading skills,[24] although, again, the reading tends to be "how-to" reading, not school-type fact-based reading.[25]

Rusty Skills

☞ Adults who dropped out of school many years ago will have lost some of their thinking skills.[26] For example, reading comprehension drops about one grade level for every year after high school for people who do not continue to read (either in further education, at work, or recreational reading).[27] Adults are also overall less even across skills, such as reading, writing, and math, than children are.[28] Like other skills, school-related thinking skills will decline if they are not practiced,[29] but also like other skills they may be recovered more quickly than they were learned in the first place.

Old Habits Die Hard

☞ Children have many misconceptions that get in the way of their learning.[30] For example, many children believe that plants "eat" soil[31] or that seasons change because the Earth is closer to the sun in the summer.

ADULTS

Adults who have the same notions have had them for a long time. So these misconceptions may be harder to change and may be more of an obstacle to learning for adults.[32]

☞ Adult students may also have been using less effective **strategies** for years.[33] For example, a student who guesses words and is not comfortable sounding out words may have been doing this for 30 years! Adults may be more comfortable with less effective but familiar strategies, and less comfortable with more effective but unfamiliar strategies than children at the same reading level.

Adult Students Who Grew Up In Low-Educated Families

☞ The 1992 National Adult Literacy Survey found that there were significant differences in adult reading ability based on **parents'** education level. For example, when they compared average scores for high school graduates, those whose parents have a college degree score 12% higher than those whose parents have 0-8 years of school.[34]

☞ Patterns of child-rearing are different in different societies and different among ethnic groups and classes in the United States. Parents raise their children in ways similar to how they themselves were raised and according to their own cultural values, priorities, and skills. That is to say, we learn what our culture thinks it is important to learn.[35] Middle-class and working-class families in the United States **tend** to raise children in different ways that affect children's learning, which is not surprising given that school culture is so middle-class.[36] Both working-class and middle-class mothers pay the same amount of attention to children; touch, comfort, and interact with children just as much; and discipline children in similar ways. But in general, middle-class families:

- make more objects (toys and household items) available for children to play with;
- restrict children less with playpens, gates, and highchairs;[37]
- let children do things for themselves more, rather than doing things for them;[38]
- buy more books for children;[39] and
- talk to infants more (especially before infants can speak).[40]

In a recent study, researchers taped parents interacting with their one- to two-year-old children and found that parents in professors' households spoke about 11 million words per year to a preschool child, working-class parents spoke about 6 million words, and parents on welfare spoke only about 3 million words, or 72% less than the professors.[41] In general, poor families read less to their children (often because of work demands) and for economic reasons are not able to provide expensive enrichment activities such as academic summer programs.[42] Lower-income children come to school less prepared than middle-class children.[43] Of course, "there are many parents from lower-class homes who do an excellent job of giving their children cognitively rich experiences, and there are middle-class parents who do a less-than-adequate job of providing their children the intellectual stimulation associated with academic success."[44]

☞ Consider memory development as an example. Many parents help toddlers learn what to notice and remember by asking them questions, like "What did we see at the zoo today?" If children give incomplete answers, parents fill in the information for them. By doing this, parents help children learn how to tell a story (what details to include, what order to tell it in), and they also help develop children's memories.[45] If working-class mothers do not know it is important to talk to children,[46] especially when they are learning to speak, then working-class children may start school with less-developed understandings of narrative and poorer memories.[47]

Summary

1. On the one hand, many adult literacy students have limited background knowledge, small vocabularies, and have never done much reading. With unfamiliar topics, adults may

comprehend less than children at the same grade reading level.

2. On the other hand, adults have had many experiences in their families, jobs, and neighborhoods that children have not had. With familiar topics, adults may be able to comprehend better than children.
3. Adults do not face the memory limits that children do.
4. Adults who grew up in lower-educated families probably started school as children at a disadvantage. Their smaller vocabularies and weaker reading skills may continue to affect them as adults.

What it means for teachers

Using Adult Advantages

- Have discussions that relate the reading to students' experiences. To return to the "Tell-Tale Heart" example, ask students if they have ever done something wrong and felt guilty about it.

- When you begin teaching a topic, find written materials that reflect your students' adult interests, experiences, and knowledge, such as work life, family life, parenting, voting, aging, reproduction, medicine, religion, and so on. Most textbook materials are not specifically adult and are written for a general audience, not for the ethnic/age group you are teaching. Remember that adults will read at a higher level when they know about the topic, so you may be able to use newspaper articles, even if they are written at a high grade reading level.

- Later, push students to apply the skills they learned on familiar materials to less familiar ones. For example, you might begin a Civil War unit by reading some slave narratives, then later read the section of a GED textbook that covers causes of the war, dates, and so on.

- Build on the skills that adults have developed, such as reading bus schedules or TV schedules, to teach less familiar content.[48]

Rusty Skills

- Reassure students who have just returned to school that their skills may be "rusty," but should improve quickly.

- Discourage students from simply "telling stories" as a way to make an argument.[49] For example, many students will try to prove their arguments by giving one case study or example from their own experiences (which is not representative).

Old Habits Die Hard

- It may be more realistic to present certain topics (e.g., evolution) as an addition to students' views of the world, not to try to replace their current ideas.

🔑 Some school learning asks people to "forget" what they know about the real world. For example, a physics question might ask, "If there were no gravity . . ."[50] The more students know about the real world, the harder it may be for them to ignore what they know.

🔑 Challenge students to use better strategies but remember that this will be a struggle for them.

Advanced Skills

🔑 Students have learned many thinking skills in their daily lives; draw on these skills in your assignments.

🔑 Minimize rote facts, maximize building on previous knowledge.[51]

Making Up For Lost Time

🔑 It is not too late for students to get certain skills if they missed them as children. For example, training in word sounds and rhyming (called phonemic awareness training) can help students at any age.[52]

🔑 For some skills like map reading, students may be at a permanent disadvantage because of their early experiences. This does not mean they **cannot** learn the skill, but you will need to explain it more and they will need more practice to learn it.

Lesson Ideas

Reflecting On Learning

✍ Ask students to write about their own learning:
- What have you learned since you left school?
- What have you forgotten since you left school?
- What do you think you are good at?
- Do you think you give people good advice? About what kinds of problems?
- Are there subjects that are hard for you? Why do you think they are hard?

✍ Make a book of student writings (anonymous) to use as reading passages for the next term. Work with the writers to add new vocabulary words that make their writing more precise and vivid. You will then have a set of readings that are intrinsically interesting and about familiar topics for your next class.

Using Life Skills

✍ Do math lessons using familiar math skills, such as money. Try estimating at the grocery store, making change for subtraction, using play money for borrowing in subtraction. Later, make the transition to unfamiliar areas.

✍ Do map reading lessons using familiar areas, such as your neighborhood, city, or state. Try bus or subway maps, topographical maps, and tourist maps of your area. Later, make the transition to unfamiliar areas.

✍ With your class, make a three-dimensional model of the blocks around your school and show students how to translate a three-dimensional model into a two-dimensional map.

✍ Do science lessons using familiar materials, such as plants, cooking, or household products (watch the safety warnings!). Try baking soda and vinegar to demonstrate chemical reactions; steam, water, and ice to demonstrate states of matter; yeast, water, sugar, and flour to demonstrate metabolism. Later, make the transition to unfamiliar areas.

Old Habits Die Hard

"Whenever you teach adults something you deprive him or her [*sic*] the opportunity of discovering it."[53]

✍ Do science experiments that challenge students' misconceptions. For example, have them drop heavy and light objects and predict which will fall faster (be sure the objects have similar surfaces or else air resistance will be a factor).

NOTES

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[1] Lave, J., Murtaugh, M., & de la Rocha, O. (1984). The dialectic of arithmetic in grocery shopping. In B. Rogoff & J. Lave (Eds.), *Everyday cognition: Its development in social context.* Cambridge, MA: Harvard University Press, p. 82.

[2] Chiesi, H.L., Spilich, G.J., & Voss, J.F. (1979). Acquisition of domain-related information in relation to high and low domain knowledge. *Journal of Verbal Learning and Verbal Behavior, 18,* 257-273 and C.H. Walker, Relative importance of domain knowledge and overall aptitude on acquisition of domain-related information, *Cognition and Instruction*, 4, 1987, 25-42.

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[4] Brookfield, S. (1998). Against naïve romanticism: From celebration to the critical analysis of experience. *Studies in Continuing Education, 20* (2), 127-142.

[5] Greenberg, D., Ehri, L.C., & Perin, D. (1997). Are word-reading processes the same or different in adult literacy students and third-fifth graders matched for reading level? *Journal of Educational Psychology, 89* (2), 262-275.

[6] Stanovich, K. Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly, 21,* 360-407.

[7] Recht, D.R., & Leslie, L. (1988). Effect of prior knowledge on good and poor readers' memory of text. *Journal of Educational Psychology, 80* (1), 16-20.

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[9] Graves, M.F., Juel, C., & Graves, B.B. (1998). *Teaching reading in the 21st Century.* Boston: Allyn and Bacon, pp. 234-235 and Bjorklund, *Children's thinking,* p. 380.

[10] Sticht, T. (1978). The acquisition of literacy by children and adults. In F. Murray & J. Pikulski (Eds.), *The acquisition of reading.* Baltimore, MD: University Park Press, pp. 146-150.

[11] Flavell, J.H. (1981). On cognitive development. *Child Development, 53,* 1-10, p. 5.

[12] Siegler, R. (1998). *Children's thinking* (3rd ed.). Upper Saddle River, NJ: Prentice Hall, p. 336.

[13] Siegler, *Children's thinking,* p. 190 and Bjorklund, *Children's thinking,* p. 9, 89, 233, 243, and 344.

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[14] There is some debate about whether problem-solving can improve. See Gruber, H.E., & Richard, L. (1990). Active work and creative thought in university classrooms. In M. Schwebel, C.A. Maher & N.S. Fagley (Eds.), *Promoting cognitive growth over the life span*. Hillsdale NJ: Erlbaum, p. 147.

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Fact Sheet 12: The Importance of Teaching Content—A Summary

Principle: Facts are just as important as skills for learning

> "Desire of knowledge, like the thirst of riches, increases ever with the acquisition of it."—Laurence Sterne (1713-1768)

Questions for teacher reflection

✎Think about a subject you know well. Imagine reading a book about it. Do you think you will understand it well? Do you think you will remember what you read? Do you think you could solve problems in that subject well? Why or why not?
✎ Think about a subject you do not know much about. Imagine reading a book about it. Do you think you will understand it well? Do you think you will remember what you read? Do you think you could solve problems in that subject well? Why or why not?
These questions got you to think about the importance of background knowledge.

What we know

This fact sheet summarizes a thread that runs through many of the previous fact sheets: the importance of content knowledge about a subject for memory, learning, and problem solving.

Students Who Learn Content Read Better

☞Students in "general literacy" classes, "general vocational education" classes, or "general ESL" classes do not improve their reading nearly as much as students in classes who study a specific subject (like cooking or electronics) as a way to learn reading. Students who are in **content-based classes** can improve their reading by up to 43%-129% more than students in general classes![1]

☞ Why are content-based classes so much more effective? There are probably many reasons, but two of the most important are:

- Background knowledge that students bring to the reading and that increases as they read and
- Using readings that are interesting to students and that motivate them to learn.

This fact sheet summarizes the importance of background knowledge. Fact Sheet 17 focuses on how motivation affects thinking and learning.

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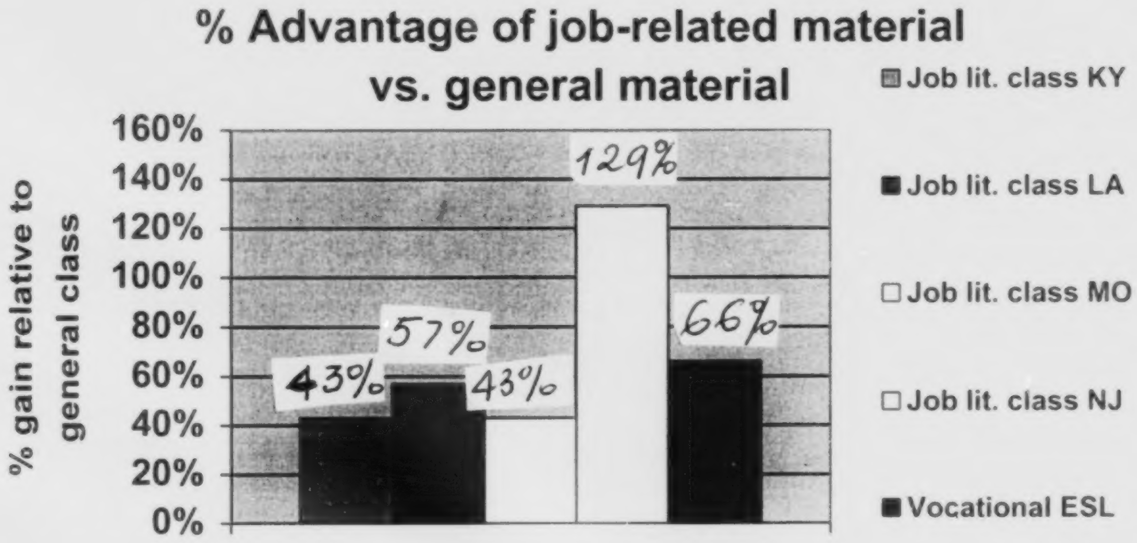

Two Dozen Reasons Why Background Knowledge Is Important

Background knowledge improves memory

1) **Background knowledge helps get information into short-term memory.** For example, every time you see a plant, your past knowledge of plants is activated from your long-term memory.[2] People learn more slowly when there is a big gap between what they know and what they are learning.[3]

2) **Background knowledge stored in mental models frees up working memory**. Because a mental model is made up of what we know about a situation, we do not have to pay attention to those details.[4]

3) **Background knowledge helps get information into long-term memory.** Relating new facts to what you already know is a much more effective way to remember than simply repeating the information.[5] Several memory techniques work because they associate new information to information already in memory. People with more background knowledge remember more of what they read.[6]

4) **Background knowledge helps students imagine a situation in their minds, which helps them remember.** But students without the background knowledge will not benefit from this strategy. For example, asking students to imagine a science description in their minds will not work if they have poor background knowledge about the science topic.

Background knowledge helps you understand what you read

5) **Background knowledge about sounds (called phonemes) helps people make sense of what they hear and read.**[7]

6) **Background vocabulary knowledge helps people make sense of longer sentences.** Students with small vocabularies have trouble reading. The new vocabulary words take up space in working memory, so there is not much left to figure out the meaning of the sentence.[8] Once students have larger vocabularies, it is easier for them to understand what they read and learn even more.[9]

7) **People with more, better organized background knowledge understand what they read better.** To understand what we read, we need to draw on all of our knowledge about the topic. Even a simple sentence such as "The truckdriver stirred the coffee in his cup." requires a "drinking model" in order to understand that the man must have had a spoon.[10] In fact, good readers sometimes make mistakes by inserting background knowledge.[11] For example, a reader may think that the "coffee" sentence specifically mentioned a spoon.

8) **Background knowledge helps students understand maps, graphs, and other graphics.** For example, a student may not be able to answer a question about a map unless he or she knows that U.S.S.R. stands for the Soviet Union, which Russia was part of.

9) **Background knowledge helps students read for meaning, which helps get information into memory**.[12] It is hard to read for meaning if you are totally unfamiliar with the topic.

10) **Students read faster, understand more, and draw more logical conclusions in familiar subject areas**.[13] Background knowledge is part of what makes a subject area "familiar."

ADULTS

11) **Background knowledge gives adult literacy students a basis for understanding somewhat more sophisticated reading materials about familiar topics than children at the same grade reading level.**[14]

Background knowledge helps people think better and do better at solving problems

12) **Background knowledge helps people know what to notice in a problem.** Experts are better than beginners at knowing what they need to notice when they learn or study. For example, an expert baker knows that it is important to ask how old a container of baking powder is, but it does not matter whether it is an ammonium baking powder or not.[15]

13) **Background knowledge is stored in mental models that affect what we see and hear.** For example, people give very different summaries of the exact same story when it has

the title "Going Hunting" than when it has the title "An Escaped Convict."[16] Their "hunting model" and "escaped convict model" shape how they understand the story. Likewise, people's mental models shape what they pay attention to when they read. Musicians remembered musical details and others remembered card details when they read a passage including, "Early in the evening Mike noticed Pat's hand and the many diamonds. As the night progressed the tempo of play increased."[17]

14) **People answer questions more logically in areas in which they have background knowledge.** A logic problem that asks, "Which of these people is allowed to drink alcohol?" is easy to solve. But very few people do well on problems that use the identical logic but are in unfamiliar settings,[18] such as "Which letter needs more Italian postage?" (although it is easier for Italians than for Americans!).

15) **Background knowledge about types of problems helps people solve problems.** For example, there are four common types of arithmetic word problems. Good word problem solvers can read a problem (often just the first few words)[19] and know how to solve it because they match it to a type of problem.

16) **However, background knowledge that includes misconceptions can get in the way of learning.**[20] For example, students who think that heavy objects fall faster than light objects will have trouble learning about gravity.

17) **Having background knowledge allows students learn from analogies.**[21] A student cannot learn about the structure of an atom from an analogy with the planets unless the student already knows about the planets. Students who know "grocery store math" can build on that knowledge to learn "school math."

18) **Background knowledge helps students understand metaphors and figurative language.**

19) **A lot of background knowledge is specific to different topic areas, so students need to get background in many subjects**.[22] Social studies knowledge does not help much with math, and math does not help much with social studies.

20) **Students can transfer knowledge better from one subject to another when they have a good understanding of the subject they are transferring from.**[23]

Background knowledge affects students' use of strategies

21) **Background knowledge helps students learn strategies because they must have something to use the strategies on.**[24] For example, students can only practice predicting what will happen next in a story if they have some experience of stories.

22) **New knowledge forces students to learn new strategies**.[25] Map reading is not needed until students depend on maps.

126

Background knowledge helps you know what to notice

23) **Experts have more subject knowledge than beginners,** which helps them notice patterns in a new situation.[26]

24) **Background knowledge helps learners see what is important in a situation and what is trivial.** For example, a three year old may think that only women use vacuum cleaners because she has only seen women use them. An older child has seen many more people vacuuming and understands that the important thing about vacuum cleaners is that they clean, not that women use them.[27] It is the varied experiences (and often parents' feedback) that lead the child to see the important aspects of the situation.[28] Some of our students' limited reasoning has to do with their limited background knowledge.[29]

Summary

1. Background knowledge affects memory, reading comprehension, problem solving, use of strategies, and knowing what to notice.
2. While our adult literacy students have some knowledge that children do not have (e.g., about work), they may also have very limited knowledge outside of their own narrow experiences.

What it means for teachers

Teach More Facts

🔍 Teach students more facts, and teach facts in the context of using skills.

🔍 Teach students the facts that they want to know and that are relevant to their lives. For example, identical biology vocabulary might be better learned in a pre-health careers class than in a "biology" class.

🔍 Hold students accountable for learning facts. Do not use information just as a means to teach skills.

Lesson Ideas

A Model For Content-Based Lessons

✍ Begin by asking students what they want to learn about, "What have you always wanted to know about . . ."

✍ Ask students to set specific, concrete learning goals, "By the end of March, I want to have learned 40 new medical terms."

✍Explain what your expectations are, "By the end of March, I expect you to be able to define and spell 40 new medical terms that are relevant to your work."

✍Use real-life reading materials for your lessons—a job policy manual or training manual, an instruction booklet for a piece of equipment, a letter that a student has received, and so on. Create questions about the reading that require students to use the factual information in the readings.

✍If students have a GED goal, also use **some** GED textbook materials, content, and practice questions.

✍Have students practice using their new skills and knowledge in several realistic applications in a real-life context—using a form, writing a memo, making a diagram or chart, reading an article and responding, explaining the material to someone else, and so on. Give specific, concrete feedback along the way.

✍End with a final project, test, or other assessment and give specific, concrete feedback about how students performed relative to their and your learning goals.

✍Begin again!

NOTES

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Fact Sheet 13: What Does Good Thinking Look Like?—A Summary

Principle: Experienced thinkers integrate knowledge and strategies

After seeing videotapes of a classroom:

Beginning teacher--	Experienced teacher--
"I can't tell what they are doing. They are getting ready for class, but I can't tell what they are doing."	"The students' note taking indicates they have seen sheets like this and have had presentations like this before; it's fairly efficient at this point because they're used to the format they are using." [1]

Questions for teacher reflection

- What are some things you are really good at? (Economics? Baking? Skiing?)
- What makes you good at these things? That is, what can you do that other people cannot?
- How did you become good at these things?
- When you think of people who are good at things that you are not good at (like theoretical physics or concert musicians), what characterizes those people?
- How do you think they got to be so good?

What we know

What Can Good Thinkers Do?

☞We all want our students to become good thinkers. But what does that mean? What do good thinkers do that beginners do not? What thinking skills would we like our students to have? Research in many different areas shows several common abilities among experienced thinkers and which we would like students to develop:

Beginners (our students)	**Experienced thinkers (what we want our students to become)**
No patterns: Reading material and problems just seem like a jumble of unrelated facts. They notice or pay attention to things that are familiar, but not necessarily important.[2]	**Patterns:** They know what to notice when they are faced with a learning task, question, or problem.[4]
Disorganized knowledge: They know a few facts about the field, but these facts are disorganized.[3]	**Organized knowledge:** They know a lot of facts about the field that they work in, and the facts are very well organized.[5]

Beginners	**Experienced thinkers**
Surface understanding: They see how parts of a topic are similar, but this is a superficial, surface understanding.[6]	**Deep understanding:** They have a deep understanding of their field, and how parts of the field are connected.[10]
Few strategies: They know a few problem-solving methods for the topic, but they do not know when to apply those strategies.[7]	**Many strategies:** They know a lot of problem-solving methods for the field they work in, and they know when to apply those strategies.[11]
Not automatic: They have to work hard to do the basic skills, so all of their attention goes to this.[8]	**Automatic:** They know basic skills so well that these are automatic.[12].
Not self-aware: They are not aware of when they understand and when they do not.[9]	**Self-aware:** They are aware of when they understand and when they do not.[13]

Because of these abilities, experienced thinkers can remember more, solve problems faster and solve more problems, and come up with better solutions, which is what we would like our students to be able to do. (See pages 131-132 for more examples.)

☞In the research, experienced thinkers are called experts. But these are not all Einsteins or people at the top of their field. They are people who are very good at what they do, whether it is waiting on tables, playing chess, or reading X-rays.

☞As you know from many of the previous fact sheets, the most effective way to help students learn these thinking skills is to model the skills for them in real-life contexts and then give them a lot of practice with support and feedback.

Effects On Learning

☞ **Memory**--Beginners remember less because they approach problems with the goal of getting the answer. Experts get more information into memory because they approach problems with a goal of understanding.[14]

☞ **Mental models**--Experts' mental models are better organized than beginners'. Beginners' mental models tend to be jumbled, even if they have the same information.[15] Experts also have knowledge about when to use a mental model. For example, there is a difference between knowing how to add two fractions and knowing when to add two fractions. Knowing when to use information makes the link between "school learning" and "real life."

☞ **Specific topics**--Expert chess players are no better at science, math, or other subjects than the average adult. Expert chemists are no better at solving political science problems than college students are.[16] People who are expert at memorizing numbers are no better than average at remembering letters. Being an expert generally means being an expert in one subject. Of course, many people develop other skills while becoming an expert. For example, doctors learn how to memorize medical terms in medical school, so they probably know how they memorize effectively.

☞**Subject-specific strategies**--Being an expert includes knowing a lot of facts in a subject (like knowing the parts of speech), knowing many rules (such as grammar rules), knowing when to use those rules (for example, knowing that capitalization rules only apply to the beginning of a sentence or a proper noun). In other words, experts are not people who are good at problem solving who just happen to apply it to whatever field they are in.[17]

☞ **Using strategies at the right time**--Beginning thinkers have a few strategies, which they do not use effectively. Intermediate thinkers have many strategies, but still do not use them in the most effective way. Experienced thinkers have the most strategies, and use them in the most effective way. This pattern of beginning, intermediate and advanced strategy use is true across many different subject areas (math and reading have been studied a lot, but also spelling, writing, grammar, syntax, scientific experimentation, and even infants' methods of getting down a steep hill).[18]

☞ **Automatic**--Experts use strategies more automatically than beginners. For example, a 12th grader may add fractions more quickly than a 6th grader because the 12th grader can simply multiply faster, not because the 12th grader has more advanced math knowledge.[19]

☞ **Deep understanding**--Students often learn facts in a disconnected way and do not learn for understanding.[20] In one study of social studies knowledge, 51% of 5th graders knew something about the Declaration of Independence, but only 26% knew that it was England that the U.S. declared itself independent from.[21] Experts, on the other hand, tend to have a deep understanding of the subject, not just a superficial understanding.[22] Part of the problem, of course, is that many teachers do not teach for understanding. Teaching for understanding takes longer than teaching by rote.[23]

ADULTS

Our adult students are probably all expert at something (perhaps cooking, sports knowledge, or living on a tight budget). We can use this expertise to help students understand what being an expert at school subjects is like.

How Does An Expert Learn What To Notice?—Examples From Physics

☞Consider the following word problem:

> Two railroad trains pull out of stations 50 miles apart at the same time, traveling at 25 miles per hour. At the same time, a bird leaves the first station flying at 100 miles per hour until it reaches the second train, when it turns around and heads back to the first train, and so on. How many miles has the bird flown when the trains meet?[24]

If the first thing you noticed about this problem was the distance the bird flies (what beginners notice), this would be a very hard problem. But if the first thing you noticed was the time the trains traveled (one-half the distance at 25 mph = one hour), it would be an easy problem (the answer is 100 miles). Michael Posner uses this as an example of the importance of what we notice in a problem.[25] A beginner sees a swirling mass of numbers, and picks the ones that "seem" right to use. An expert physics problem solver knows what numbers in the problem are relevant or not, and knows how to draw a diagram to represent the problem.[26] Where a beginner sees random numbers, an expert sees how the numbers fit into patterns (such as distance increasing with acceleration) and knows the significance of these patterns.[27]

☞Experts do not become that way by "acting like experts." Rather, they learn what to notice by:

- **Watching** teachers who point out what to notice (e.g., "This is the most important thing here."),[28]
- **Doing** a lot of problems,[29]
- **Getting feedback** on their work. (e.g., "The distance is important, but I think the time is even more important."),[30] and
- **Talking** about **how** they chose the most important information (e.g., "I agree that these are the right numbers to use, but why did you choose them?").[31]

How Does An Expert Get Organized Subject Knowledge?—Examples From Poetry

☞An expert and a beginner who read the same poem may find a very different meaning.[32] The beginner may be able to understand what is happening in the poem and with some effort can do some "reading between the lines." But this subject knowledge is not well-connected. The beginner may have preconceptions about poems ("They are easy because they are short") that may get in the way of understanding. The expert can relate the poem to the poet's life and work, literary movements of the time, the literary conventions of poetry, and so on. The expert has a lot of organized factual knowledge that helps him or her to see very different meanings in the poem than the beginner does.

☞Experts learn subject knowledge by:

- **Watching** what teachers emphasize (e.g., "Notice again the use of metaphor here."),
- **Reading** a lot,
- **Getting feedback** on how organized their ideas are (e.g., "You explain the metaphors well, but you do not relate them to other poets' use of metaphors."), and
- **Discussing** the connections among what they read (e.g., "How does Langston Hughes' poem reflect what was going on in America at the time?").

Just presenting an organized body of knowledge is not enough. Students have to be actively involved in organizing their own ideas before that knowledge will stick.[33]

How Does An Expert Get A Deep Understanding?—Examples From Interpreting X-Rays

☞A doctor who is an expert at reading X-rays understands, for example, how different parts of the body work together, how the parts of the body normally look on an X-ray, and how different medical problems show up on an X-ray.[34] For the expert, these three bodies of knowledge are not separate, they are interconnected in many ways.[35] This is very different from the American history student used as an example in Fact Sheet 3: Mental Models, who did not connect the Revolutionary War with the United States becoming a country![36] This student related surface features, like Columbus sailing to America and pilgrims sailing to America. In general, experts read for understanding more than beginners do and remember more of what they read.[37]

☞ Experts get a deep understanding by:

- **Watching** teachers explain the deep connections among systems (e.g., "Notice how the X-ray shows the lungs in front of the heart."),
- **Practicing** a lot,
- **Getting feedback** on how deep their understanding is[38] (e.g., "You explained how the X-ray was taken but you did not relate it to anatomy in your discussion."), and
- **Discussing** the connections among systems (e.g., "Why do you think a resected lobe looks this way on the X-ray?").

How Does An Expert Learn Strategies?—Examples From History

☞ Beginning history students see history as a collection of facts, not as an interpretation of actions and events from the past. So their problem-solving strategies are limited to looking up facts and putting them in chronological order. Expert historians, on the other hand, have many problem-solving strategies, which they know when to use. Strategies include:

- using a range of materials (books, newspapers, letters, commentary, popular culture, and so on),
- identifying implicit messages in written or spoken materials,
- relating messages to the motives of the speaker or writer, and
- identifying themes (freedom, independence, and so on).

One study compared expert American historians to undergraduate history majors. The experts actually scored lower than the undergraduates on a test of facts and dates, but scored much higher when they were asked to interpret the significance of a document. The experts were able to relate the document to different movements of the time, compare and contrast it with other documents, and interpret its meaning in terms of historical trends.[39]

Experts learn strategies by:

- **Watching** experts model strategies (e.g., "Notice here that King is using language from the Bible."),
- **Practicing** using strategies ("Why do you think King used the example of eating together?"),
- **Reading** many, many primary historical documents and historical analysis, and
- **Discussing** issues of history interpretation ("I agree with you, but what is your evidence for the argument that King was trying to build a multi-racial coalition?").

How Does An Expert Develop Automatic Skills?—Examples From Arithmetic

☞ Beginners who do not know their multiplication tables will be very slow at working with fractions. Students who are experts at fractions can do basic arithmetic almost automatically, without having to think about it. Similarly, very fast readers do not have to think about decoding every word, but effortlessly and almost instantly recognize most words.[40] The advantage of learning basic skills so well is that this frees up short-term memory so the learner can consider more information at once. The expert fraction student can focus on whether she understands the fraction word problem because she does not have to give attention to how many 12s fit into 48, she just knows that math fact.

☞ Experts at fractions learn to do basic arithmetic automatically by:

- **Watching** experts draw on automatic skills and seeing that it is much more efficient,
- **Practicing** basic skills over and over again by doing meaningful problems, and
- **Practicing in smart ways**, by figuring out what learning strategies work for them (rhyme, pictures, noticing patterns [such as 5s and 9s in multiplication], concentrating on what they do not know, and so on).

How Does An Expert Become Self-Aware?—Examples From Writing

☞ Beginning writers think that writing means "telling what you know."[41] They do not see writing as making a persuasive argument for a particular audience. So they are not aware when their writing is clear. Expert writers know when their writing is clear and when it is not (as well as when they understand the topic they are writing about and when they do not). They are aware of who their audience is, its background knowledge, appropriate communication strategies, and whether their writing has taken those into account, and done it in a grammatical, elegant way.

☞ Experts learn to be self-aware by:
Observing experts' self-awareness (e.g., "Now here I'm not sure whether 'understated' or 'subtle' would be the better word."),
Practicing being self-aware as writers ("Why did you use the word 'subtle' here?"),
Reading many, many books, and
Discussing what makes writing effective ("I agree with you, but what did the author do here that persuaded you much better than the other essay?).

Summary

1. Experts do not just have more knowledge than beginners, nor were they just born with exceptional talent. Experts practiced their skills a lot.
2. Experts know what to notice in a problem.
3. Experts have very organized knowledge.
4. Experts' knowledge is deeply interconnected.
5. Experts have many strategies, which they know exactly when to use.
6. Experts have practiced their basic skills so much that they are automatic.
7. Experts are very aware of their own thinking—they know when they don't know.
8. People become expert by observing experts, learning strategies and facts for specific subjects, solving problems, getting feedback, and talking about why things are the way they are.

Characteristics of Beginners and Experts

	Computer Programmers[42] Beginners	Experts	**Doctors (X-Ray)**[43] Beginners	Experts
Know what to notice	Can't tell "good code" from "bad code." See "code" line-by-line.	Can tell "good code" from "bad code." See "code" in chunks.	Look at an X-ray, but do not know what it is showing--a tumor? a disease?	Know what the X-ray is showing--what X-ray should look like vs. what it does look like.
Organized knowledge	Take a long time to find "bugs" that cause program to fail. Do not understand how parts of a program work together.	Can see where "bugs" are that cause program to fail. Understand how parts of a program work together.	Do not relate X-ray image to broken bones, diseases. Explanations do not connect body systems (bones, muscles, ligaments).	Relate X-ray image to broken bones, diseases. Explanations connect body systems (bones, muscles, ligaments).
Deep under-standing	See parts of a program in terms of how they look. Search for formulas that fit how the program looks, not how it functions.	See parts of a program in terms of how they function.	Relate image to body parts, but not functions of parts.	Relate image to functions of parts (torn ligament destabilizes joint).
Strategies	Have only a few programming strategies. Do not know how to choose which strategies to use. Choose familiar strategies.	Have many programming strategies for any sub-problem. Know which strategies are likely to be effective.	Have few strategies for diagnosing problem. Do not know when to use another technique (MRI).	Have many strategies for diagnosing problem. Know when to use another technique (MRI).
Automatic	Have to painfully think through basic code-writing elements.	Do not have to think through basic code-writing elements.	Have to painfully think through problem to figure out what is going on.	Can see what is going on "at a glance."
Self-aware	Do not know when the program is working or not.	Know when the program is working or not.	Do not know when they need a consultation.	Know when they need a consultation.

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	Teachers[44] Beginners	Experts	**Reading comprehension**[45] Beginners	Experts
Know what to notice	See the classroom, but do not know what to notice. See classroom student-by-student.	Know what to notice in a class--body language, noise. See classroom as a whole, not student-by-student.	See all text as the same. Skip headlines, captions, summaries, and so on.	Read headlines, captions, summaries, and so on. Notice organization of text (sections, chapters).
Organized knowledge	Do not connect observations with what they know about teaching. Do not know what topics students are likely to have trouble with.	Interpret observations--are students working? Do they understand? Know what topics students are likely to have trouble with.	See all information as new or related to "common sense." Read passively and expect to "learn" from text without thinking about it.	Relate new reading to prior knowledge. Create mental models of text (or diagrams, outlines if needed).
Deep under-standing	Do not connect class events to overall learning goals.	Know how what is happening in class relates to overall learning goals.	Read to "get through."	Read for understanding.
Strategies	Have few ways to explain topics, not aware of dis/advantages of each method. Have few and ineffective strategies for managing classroom.	Know many ways to teach any topic, and dis/advantages of each method. Explain why they are covering a topic. Have many strategies for managing classroom.	Have few reading strategies and guess about which to use.	Have many reading strategies (dictionary, sound out, and so on) and know when to use them.
Automatic	Need to reason through step-by-step in order to figure out what is happening.	Recognize what is happening quickly.	Need to consciously, slowly, effortfully make sense of what they read.	Can make sense of most texts without having to consciously think it through.
Self-aware	Do not know whether they are getting through or not.	Know when their teaching methods are working or not.	Are not aware of whether they understand or not.	Know when they are understanding or not.

What it means for teachers

Five Principles

- **Model** what you want students to do ("Notice that . . .").
- Give students lots of chance to **practice**.
- Give **feedback** that relates to students' deep understanding ("Does that make sense . . .?").
- Ask them to **read** a lot, to develop students' knowledge base.
- **Discuss** everyone's answers, right and wrong ("I agree with you, but why . . . .?).

Learning What To Notice

- Point out what details your students should notice, and which ones are not relevant. Help them "see the forest for the trees."

Learners' Preconceptions

- Figure out what preconceptions will interfere with your beginners' learning. A few examples are:

Writing--purpose: good writing means telling what you know
Reading: Good reading means pronouncing the words right
Biology--evolution: creationism
        --**animal behavior:** animals have human motivations
Chemistry--reactions: chemicals behave like water, common substances
Physics--gravity: heavy objects fall fast

- There are several different ways to address preconceptions:

1. Create experiments or experiences that contradict those preconceptions, make predictions, then discuss the results.
2. Acknowledge the preconceptions and then present an alternative view and the evidence to support it ("Many people think . . . ").
3. Model a different way of approaching the topic and ask students to follow the model (e.g., an essay format rather than "knowledge telling").

Organized Knowledge

- Help students learn more facts--most textbooks do not have enough detail.[46] Supplement them with magazine articles, information from the Internet, and so on.

- Help students organize what they know. See Fact Sheet 3: Mental Models.

Deep Understanding

- Focus on the core concepts in your subject that tie it together, such as figurative language in literature, adaptation in biology, or gravity in physics.

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🔑 Be sure that the questions you ask go beyond understanding facts, and ask for a deep understanding of the topic. Think of questions that take the form, "How does . . . relate to . . ." or "What is the connection between . . . and . . ."

🔑 See Fact Sheet 5: Getting Information into Memory.

Strategies

🔑 Give problems that make students stretch beyond the strategies that are easy for them. See Fact Sheet 4: Thinking About Thinking.

🔑 Teach one new core problem-solving strategy for your topic every term (such as summarizing or estimating). See Fact Sheet 4: Thinking About Thinking.

Making Basic Skills Automatic

🔑 Make repetition meaningful and interesting. See Fact Sheet 5: Getting Information into Memory.

🔑 Continue to practice basic skills after they are first mastered.[47] (Musicians play scales their whole lives!) See Fact Sheet 8: Long-Term Memory and Learning.

Self-aware Thinking

🔑 Ask students to explain every answer to you, whether you think the answer is right or wrong.

🔑 Be sure that some of your questions go beyond knowing facts and get students to explain their understanding of the topic and become aware of their own thinking. "What are the differences between a state and a county?" is a very different question from "Why do we have states and counties?".

🔑 Ask students to write about all subjects, not just GED essay topics.[48] "Why" questions make them aware of what they understand and gives them practice with the way arguments are made in the field (making a biology argument is different from making a psychology argument).

Lesson Ideas

Term Project

✍Consider doing a relatively long project that allows students to:[49]

1. Learn more facts about a topic.
2. Confront their preconceptions about the topic.
3. Get lots of practice in solving complex, real-world problems.
4. Discuss their decisions and get feedback.
5. Write about the topic or do a presentation, model, or other product.

You will probably need at least 20 hours of class time (spread out over 2-10 weeks) to cover all of these areas.

✍ Some possible topics include:
Writing: Writing a history of your school and putting it in the context of adult education in the U.S.
Social studies: Education and income in the U.S. Who gets what kinds of education? How is income distributed? What are the relationships between the two?
Biology: Growing different types of plants and considering what helps them grow
Chemistry: The chemistry of water (states of matter, solubility, weather, and so on)
Physics: Gravity (falling objects, weight, planets, outer space)
Be sure that your students are interested in the topic, and that you tie it into their goals (e.g., with sample GED essays, sample GED problems, and so on).

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Fact Sheet 14: Critical Thinking

Principle: People Make Predictable Types of Thinking Mistakes

> "Whenever there is a simple error that most laymen fall for, there is always a slightly more sophisticated version of the same problem that experts fall for."—Amos Tversky, researcher.[1]

Questions for teacher reflection

- What kinds of thinking mistakes do you think students make?
- What is your definition of critical thinking?
- Think of an area where you are a good critical thinker. How did you become a critical thinker in that area?
- Do you think that people in general are "logical" or "illogical"?
- When do you think people are generally "logical"?
- When do you think people are generally "illogical"?

What we know

What Is Critical Thinking?

☞"Critical thinking" is a term that has been used by many people in many ways. Some people use "critical thinking" to mean good thinking that avoids common mistakes in thinking. Others have more specific definitions; you will find several definitions at the end of this fact sheet. This fact sheet summarizes ten thinking mistakes that most people make.

☞Maybe the easiest way to define critical thinking for the GED is what it is not. GED students make the same types of thinking mistakes that everyone makes, but they have less background knowledge, so they make more mistakes. Common thinking mistakes that people make are:

1. coming to a favored conclusion without looking at the evidence[2]
2. not following logic when they disagree with a logical conclusion[3]
3. choosing the most familiar answer[4]
4. not plugging in information that would disprove their own theory[5]
5. not noticing details
6. not considering other points of view
7. not noticing whether they understand or not[6]
8. giving in to frustration and guessing or not thinking
9. assuming the answer or outcome they expect
10. basing opinions on the credibility of the speaker, not on the evidence

Coming To A Favored Conclusion Without Looking At The Evidence

☞ People routinely agree with an argument and do not look at the evidence--really they just agree with the conclusion.[7] In one study done during World War II, people were asked what conclusion they could come to after reading, "Patriotic citizens are not executed by firing squads; since most patriotic citizens are not like the saboteurs landed on our shores by Nazi U-boats: [choose a conclusion]" Ninety-five percent of people chose, "The saboteurs . . . will [or may] be executed." None of the choices were logical conclusions from the two statements.[8] Rather, people answered based on their personal feelings about Nazis. When they answered a question that was logically the same, 'A's are not B; since most Cs are not the opposite of A, then [choose a conclusion],' only 14% chose the equivalent answers ('The not-As may be B').

$$\text{Argument} = \begin{array}{c}\text{Evidence}\\ \underline{+\ \text{Evidence}}\\ \text{Conclusion}\end{array} \quad \text{OR} \quad \begin{array}{c}\text{Premise}\\ \underline{+\ \text{Premise}}\\ \text{Conclusion}\end{array}$$

☞ In our classrooms, a GED student may agree with an author's conclusion even though the author has not made a sound argument.[9] Perhaps the author feels that parents should have a choice of schools because then students would be better behaved. The conclusion is not well related to the argument (the point of school is to learn, and behavior is only a small part of that), but the student agrees with the conclusion to begin with, so he or she does not evaluate the argument. This happens more often with highly emotionally charged issues like religion, abortion, or gun control, than with emotionally more neutral topics.[10]

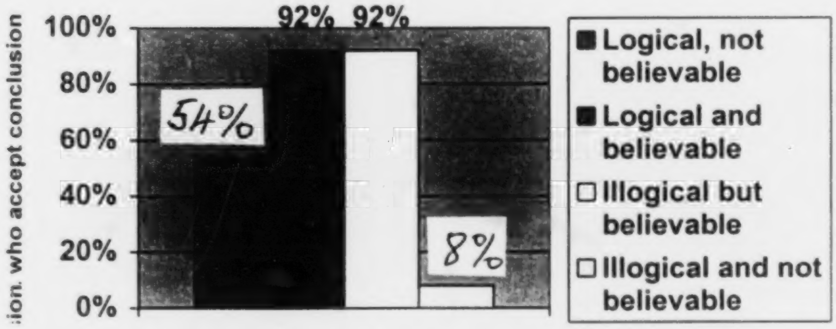
☞ To think well, students need to look at the relationship between the evidence (the premises) and the conclusion, whether or not they agree with the conclusion. In this example, the student needs to explain how the evidence supports the conclusion. If it does not, the student can look for more evidence (Under what school conditions do children learn best? What are the outcomes when there is school choice?).

☞ Background knowledge plays a role in evaluating conclusions--students with a lot of background knowledge know a larger range of possible outcomes and opinions (See Fact Sheet 12: The Importance of Teaching Content for more information). Students with less background knowledge may think that "a reasonable person could only possibly agree with me," and may not know of other ways that things could be done.

Not Following Logic

☞ This mistake is the other side of the coin from the previous one. People often say an argument is illogical when they disagree with the conclusion. In one study, 54% of people said they could not accept a logical conclusion when it was not believable (e.g., "Some cigarettes are not addictive"). Ninety-two percent accepted a logical conclusion when it was believable ("Some addictive things are not cigarettes"). And 92% accepted an illogical conclusion when it was believable![11]

People Do Not Follow Logic, They Follow What They Already Believe



☞ Imagine a GED student whose family member has been murdered and who supports the death penalty. When the student sees the argument, "The death penalty is cruel and unusual punishment. The constitution prohibits cruel and unusual punishment. Therefore, the death penalty is unconstitutional.", he or she may say that the argument is not logical because the student disagrees with the conclusion.[12] In fact, the argument is logical, but the student disagrees with the premises of the argument (perhaps he or she thinks that the death penalty is not cruel compared to the family's own loss).

☞ To think well, students need to look at how the parts of an argument relate to the conclusion, and whether or not they agree with the premises of the argument. In this example, students could understand that the argument is logical, but they disagree with the evidence.

☞ Background knowledge plays a role here too. A student with lots of background knowledge can understand that another person could reasonably come to this conclusion, even though he or she disagrees. A student who is surrounded by people who all have the same opinions will have more trouble seeing that other arguments can be logical, even though the person disagrees.[13]

Choosing The Most Familiar Answer

☞ People routinely remember or choose the answer that is most familiar.[14] For example, when people are asked to remember a list of names that includes celebrities, they remember the celebrities' names better than the other names. People also overestimate how common plane crashes, cancer, and other relatively rare events are and underestimate how common diabetes, asthma, lightning strikes, and other events are.[15] Media coverage makes certain events seem more common than they are; from 1990 to 1998 murders went down by 20% but network TV news coverage of murders went up by 600%.[16] So murder seems more common than it is because TV coverage makes it so familiar.

☞As an example of choosing the most familiar answer, a class of mine was reading a book review about a mother who returned to her daughters after having abandoned them. One student said that the daughters welcomed the mother back. In fact, the review had said the opposite--the daughters were resentful of their mother for having abandoned them. But the student was not able to get past the familiar "fairy tale" ending that she had expected and understand what the author had actually said.

☞To think well, students need to imagine many different outcomes, not just the most familiar or desired ones. In this example, the student could have imagined all of the outcomes (the daughters were happy, neutral, or unhappy) and then re-read the passage to find out what the author actually said.

☞Prior knowledge also plays a role in choosing familiar examples.[17] To a student with a lot of background knowledge, many things are familiar, so the student has many choices. But a student with very little background knowledge will return over and over again to the same few familiar answers.

Not Plugging In Information That Could Disprove Their Own Theory

☞ Most people test an idea by trying out examples that prove the idea, not disprove it.[18] For example, a person may test the idea that "cramming helps people learn" by cramming, not by getting a good night's sleep and seeing if he or she does well on the test anyway. Choosing only evidence that proves your own point is a good way to maintain stereotypes. For example, people who say "those immigrants are all drunks" only notice people who drink in public. They do not notice all of the immigrants who are indoors and who do not drink.

☞ People are better at testing ideas if the subject is familiar. In one experiment on an unfamiliar subject, people had to figure out which card or cards to turn over to prove the rule, "If a card has a vowel on one side, it must have an even number on the other side." If the cards are A, 6, J, and 7, people should have said, A (to test if there is an even number) and 7 (in case there is a vowel on the other side). Only 4% answered correctly.[19] In a familiar setting, an experiment used logically identical examples about whether people in a bar can legally drink ("Who should you check, a beer-drinking person, a 22 year old, someone drinking a soda, or a 16 year old?"). 73% answered correctly when the example was familiar.[20]

An unfamiliar example (4% correct):

"If a card has a vowel on one side, it must have an even number on the other side." Which cards should you turn over to check?

A 6 J 7

From Wason (1968)

A familiar example (73% correct):

"You must be over 21 to drink alcoholic beverages." Which people should you check?

Drinking a beer	22 yrs. old	Drinking coke	16 yrs. old

From Griggs & Cox (1982)

☞ In our classrooms, in a discussion about how police treat people, GED students may say "Police are always unfair," and give examples of when they or their friends or family have been treated unfairly by police. But they do not consider times when police have helped them, their friends or family, or anyone else for that matter.

☞ To think well, students need to imagine what kind of information could disprove their argument, and test it out. To use a simple example, imagine you make up a number pattern such as "any three whole numbers arranged from smallest to largest" (such as "3, 27, 289" or "16, 58, 67"). A student is trying to guess the rule, and tries "1, 2, 3." You say yes, so the student tries "5, 6, 7" and "19, 20, 21." The student is sure that the rule is "three numbers in order," but hasn't tried any pattern that would disprove that rule. In the police example above, students could imagine times when police could have helped people, find out if that has happened, and maybe modify their argument ("Police have biases against some groups that lead them to treat members of those groups differently and unfairly, quite often in some places.")

☞ Background knowledge plays a role here, too. Students with a wide range of personal experiences can imagine (or have experienced) evidence that could disprove their own explanations. Students with a narrow range of experience have a hard time imagining that things could be different from their own experience.

Not Noticing Details

☞ Beginners often do not know what details to notice when they are faced with a problem. Experts know what to notice, and they see meaningful patterns (See Fact Sheet 13: What Does Good Thinking Look Like: A Summary). Sometimes students do not notice details because they do not know what to look for. For example, in proofreading they may skip over a word that is missing an "s" at the end because they are not aware that they need to check for subject-verb agreement.

☞ To think well, students need to practice noticing the details that are considered important in each subject. What is important in economics may be a distracting detail in biology, and vice versa. (See Fact Sheet 1: Literature is not Science.)

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Not Considering Other Points Of View

☞Many people have trouble seeing things from another person's point of view.[21] Many GED students have a narrow range of experience, and have not met many people who look at the world differently than they do. Many GED questions ask students to take another point of view, e.g., "Which of the following statements would the author most likely agree with?" My students who saw a cartoon about the government experience of political candidates and were asked about the cartoonist's opinion had a hard time eliminating a religious leader from the choices. In their communities, all religious leaders are considered good political candidates.

☞ To think well, students need to practice imagining what another person is likely to believe and explaining why. In the case above, the cartoonist thinks that only people with government experience are qualified for political office, therefore the cartoonist would believe that the religious leader is a poor candidate.

ADULTS

Adult literacy students' lack of background knowledge makes them prone to many thinking mistakes, especially belief biases, the availability heuristic, and confirmation biases.

Not Noticing Whether They Understand Or Not

☞ Beginning learners are usually not aware of whether they understand.[22] They do not know when they need to re-read or ask themselves questions to check whether they understand.[23] (See Fact Sheet 4: Thinking About Thinking for more information.)

☞ To think well, students need to practice checking whether they understand or not and practice asking themselves questions.

Credibility Of The Speaker

☞ People sometimes believe things because they trust the person who said them, even if the person has no expertise in that area.[24] For example, they may believe a barber's opinion about the benefits of a vitamin, even though the barber has only personal experience and does not know anything about whether the vitamin has been studied or tested. People underestimate how random small samples of personal experience can be, and put more trust than they should in their acquaintances' experiences.[25]

☞ To think well, students need to look at the speaker's background in the area: does he or she have experience and education in that particular topic?

Summary

1. Everyone makes thinking mistakes, and in fact, everyone makes the same kind of thinking mistakes.
2. In general, people make fewer thinking mistakes in familiar areas, and more thinking

mistakes in unfamiliar subjects.

3. Many people agree with an argument if they agree with the conclusion (and vice versa), regardless of whether good reasoning was used.
4. People routinely choose the most familiar answer if they do not know how to solve a problem.
5. People tend to look for evidence that would prove their own theory, not disprove it.
6. People fail to notice details unless they have been taught which details to notice.
7. Many people have a hard time seeing a situation from another person's point of view.
8. Beginners in a field are usually unaware of whether or not they have understood something.
9. People usually believe things that are said by people who they trust (regardless of that person's knowledge).
10. The more schooling people have (i.e., the more exposure they have to these specific kinds of problems), the less they make these mistakes.

What it means for teachers

To learn to think well, students need to practice making arguments and getting feedback on their ideas.

Evidence And Conclusions

Students need practice in explaining the evidence that backs up their positions. For example, a student who says that "AIDS is a government plot" should be asked to give the evidence for that (Are there people who worked in the government labs? Did the disease show up in all of the places with "target groups"?)

Logical Conclusions

Ask "why?" Always ask students to explain how their answers follow from the evidence, even if you agree with the conclusions and the evidence. For example, if a student says that "the Earth is round because otherwise you would fall off the edge," ask how those ideas are connected. (Pictures of the Earth from space are better evidence.)

Choosing Familiar Answers

Use newspaper and magazine articles that use statistics that go against "common sense," such as rising high school graduation rates, falling murder rates, and so on.

Enlarge students' knowledge of the world, so that more things are familiar to them. For example, many urban people think there are more librarians than farmers—the opposite is true.[26]

Challenge The Evidence

Ask students to imagine what kind of information could disprove what they believe. For example, if students say that immigrants take jobs from native-born Americans, ask what kind of information could show that is not true (What types of jobs do immigrants take? Who used to do those jobs?)

Noticing Details

Point out what details need to be noticed and why, whenever you solve a problem. Also point out what information is not relevant and why. For example, on a graph that shows temperature and rainfall, it does not matter what color the graph is. But colors in a painting are very important because they convey a particular mood or feeling.

Points Of View

Ask students to take different points of view. For example, students could read opposing newspaper opinions and then have a debate on child discipline, legalization of drugs, welfare reform, or any topic where there is a difference of opinion.

Being Aware Of Knowing

Ask students to explain what they have read and what they understand. Be sure to ask "Why" questions that go beyond "What happened?" and "Who did it?". For example, in a science lesson on plants, ask students why plants get water from the soil, rather than the air.

Jumping To Conclusions

Ask students to explain the steps in their thinking. For example, if a student says "Jones will win," ask "Why do you think he will win?" If the answer is, "People will vote for him," ask, "Why do you think people will vote for him?" and so on.

Credibility Of The Speaker

Whenever students refer to a source, such as the newspaper, TV, an expert, or a friend or relative, ask them what that person knows about the topic. For example, if they refer to what their minister has said about teaching, ask if he or she has experience as a teacher, who he or she has taught (children? adults?), and so on.

Lesson Ideas

Evidence And Conclusions

Develop two-stage science experiments where students predict what will happen, observe what actually happens, discuss their predictions in light of what happened, then predict again for the same type of event, observe again, and discuss again. This can be done with falling or rolling objects, swings, plants (with light, water, or herbicides), a person's breathing rate or pulse (with exercise), and so on.

Logical Conclusions

✍ Make up examples that have a logical conclusion that your students are likely to disagree with and have a discussion about logic and conclusions. You may want to start by asking, "If you agreed with these two things, then would you agree with the conclusion?"

Challenge The Evidence

✍ Read an editorial or opinion piece from a newspaper or magazine and imagine what kind of evidence could disprove the person's argument. For even more challenge, try to find that evidence (watch out for testimonials, they are not the same as large experiments or surveys).

Points Of View

✍ Have students role play or debate a position they do not agree with (e.g., in a Revolutionary War debate, have a student play an English governor even though he or she thinks the colonists were right).

Textbooks

✍ Martha Barnes' *Reading and Critical Thinking in the Content Areas* is a GED-based critical thinking textbook that has exercises on finding the main point, noticing biases, avoiding logical mistakes, and other skills.[27] This short book is a good starting point for improving critical thinking, but students will need more practice in each subject area than this book provides.

Four definitions of critical thinking

☞The GED Testing Service defines critical thinking as being able to comprehend, apply, analyze, evaluate, and synthesize information; avoid jumping to conclusions; and avoid guessing.[28]

☞Diane Halpern defines critical thinking as goal-directed, purposeful, and reasoned; effective for the thinking context and the thinking task; and evaluating your thinking process and evaluating your answers.[29]

☞Robert Slavin defines critical thinking as: identifying misleading statements, identifying assumptions in arguments, weighing competing evidence, and identifying fallacies in arguments.[30]

☞Lauren Resnick defines critical thinking as problems that involve unknown information; require independent thinking; require judgement and interpretation; are complex and do not have an obvious answer; have many possible solutions which need to be weighed, need to be analyzed in many ways, and which can conflict with each other (what is fastest? cheapest?); require the thinker to find meaning in a lot of information, which can seem chaotic; and take hard work.[31]

NOTES

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[1] Quoted in Gardner, H. (1987). *The mind's new science: A history of the cognitive revolution* (Paperback ed.). New York: Basic Books, p. 360.

[2] Called belief bias. See Dominowski, R.L., & Bourne, L. E., Jr. (1994). History of research on thinking and problem solving. In R.J. Sternberg (Ed.), *Thinking and problem solving*. San Diego: Academic Press, p. 32.

[3] Also a form of belief bias.

[4] Called the availability heuristic (a heuristic is a problem-solving shortcut--many heuristics are valid in many, but not all, situations). Schwarz, N. (1995). Social cognition: Information accessibility and use in social judgment. In E.E. Smith & D.N. Osherson (Eds.), *An invitation to cognitive science: Vol. 3. Thinking* (2nd ed.), pp. 345-376. Cambridge, MA: MIT Press.

[5] Called confirmation bias. See Mayer, R. (1992). *Thinking, problem solving, cognition* (2nd ed.). New York: W.H. Freeman, pp. 99-103.

[6] Called metacognition. Hacker, D. (1998). Definitions and empirical foundations. In D.J. Hacker, J. Dunlosky & A.C. Graesser (Eds.), *Metacognition in educational theory and practice* Mahwah, NJ: Lawrence Erlbaum.

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[20] Griggs, R., & Cox, J.R. (1982). The elusive thematic-materials effect on Wason's selection task. *British Journal of Psychology, 73*, 704-420.

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[24] Halpern, *Thought and knowledge*, p. 179-180.

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Fact Sheet 15: Active Learning—A Summary

Principle: Active Learning is More Effective Than Lecture

> "Successful learners are active, goal-directed, self-regulating, and assume personal responsibility for contributing to their own learning."—American Psychological Association, "Learner-Centered Psychological Principles," 1997[1]

Questions for teacher reflection

- Do you think that people learn better when they take an active part in learning?
- Do you think you learn from lectures? Why or why not?
- When do you think lectures are a good way to learn?

These questions got you thinking about active learning.

What we know

Does Active Learning Really Make A Difference?

☞ Many GED teachers have an intuition that active learning—where students figure things out for themselves and participate in discussions, activities and projects—is more effective than lecture-based teaching (clearly it is less boring to students). But what is the evidence for this? This fact sheet summarizes what we know about active thinking and active learning. Project-Based Learning (PBL) and small group teaching are covered in Fact Sheet 16. Supporting good thinking is covered in Fact Sheet 17.

☞ David Garvin of the Harvard Business school suggests three reasons for promoting active learning:

- Cognitive: students have difficulty retaining information unless they use it.
- Philosophical: lecture is good for transferring information, but the goal of education is creating independent thinkers.
- Student preferences: students are bored by lectures and do not perform as well.[2]

You will find two sections below: first, the role of active participation in thinking and remembering; second, studies on active learning in the classroom.

Active Thinking

☞ A basic fact about learning is that learners add information from their own experience in order to understand what they read and hear. Experienced readers seem to do this effortlessly, but less experienced readers may need to be taught how to do this. The active thinking skills below take more hard work from beginners and take less and less conscious effort as students get more experience. So what is "active" for beginners becomes "unconscious" for experienced learners.

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☞ A word can last in working memory for about two seconds without any work. To keep a word in working memory, you need to rehearse it, like repeating a telephone number to yourself. Keeping information in working memory is an active process that uses "talking to yourself" (although your mouth does not have to move to do this).[3]

☞ More information goes into memory when people are asked to actively think about what a word means (instead of just sounding it out). In one study, people were asked "Is the word in uppercase letters?," or "Does the word rhyme with 'grog'?," or "Does this hop?," and then saw "FROG."[4] People who were asked to pay attention to meaning recognized 81% of the words later; for rhymes, 48%; and uppercase, 15%. Recognizing words is easier than repeating the whole list (just as a multiple-choice test is easier than a short-answer test). When people are asked to repeat back the list, meaning is still the best: 28% for meaning, 11% for rhyme, and 10% for uppercase.[5] In another study, people who were asked to notice whether a word was "pleasant" remembered more than twice as many words as people who just had to notice whether the letter "e" was in the word or those who had to estimate the number of letters in the word.[6] In another study, people who both rated how pleasant a word was and put the same words into categories remembered more than people who just did one of those.[7]

☞ To understand almost anything, readers must actively add information from their own store of knowledge. For example, to understand the sentence, "She broke the bottle against the bow and the crowd cheered," you must add your own knowledge about ships, the tradition of christening ships, including using a bottle of champagne, and so on.[8]

☞ People also add their own mental models to help understand what they see and hear.[9] For example, people give very different summaries of the exact same story when it has the title "Going Hunting" than when it has the title "An Escaped Convict."[10] Their "hunting model" and "escaped convict model" shape how they understand the story.

☞ Just presenting an organized body of knowledge is not enough. Students have to be actively involved in organizing their own ideas before that knowledge will stick.[11] Experts learn subject knowledge by:

- Watching what teachers emphasize,
- Reading a lot,
- Getting feedback on how organized their ideas are, and
- Discussing the connections among what they read.

☞ Just seeing new information is not enough for learning most of the time.[12] The mind has to do some work with new information before it will be reliably stored in memory.[13] For example, the mind can try to make sense of a sentence, compare a new image to a familiar one, or fit new information into a known concept. Relating new information to known even works for people with amnesia.[14] This work moves information from working memory (where it will only last 20-30 seconds) into long-term memory.[15]

☞ People remember words better when they have to figure them out for themselves. People who had to figure out synonyms, like "rapid = f____" ["fast"] remembered about 10-20% more words than people who were given the synonym to memorize "rapid = fast."[16] Students who had to figure out words with missing letters (such as tel_ph_ne for telephone) remembered 46% of the words, but people who saw the whole words only remembered 35%.[17]

☞ When people are asked to actively relate new information to what they know ("what does this make you think of, are there other words that sound like this?"), they remember about 72% of the words after 12 seconds. People who are asked to repeat the words over and over again (rote learning) remember about 35% of the words. And most people who are asked to "just remember" seem to naturally repeat the words and only remember about 5% more than those who are told to repeat.[18]

☞ In another study, people were asked to write down three words to describe a word they were learning (for example, marmalade: sticky, sweet, can be eaten) for 500-600 words. Later, they could remember 50-60% of the words after hearing one word from their own description (sticky) and 90% of the words after hearing all three (sticky, sweet, can be eaten). People who did not write down the words guessed 5% of the words after hearing one describing word (sticky) and 17% of the words after hearing all three (sticky, sweet, can be eaten).[19]

☞ Good learners are more aware of when they understand and when they do not, "these active learners are therefore likely to ask questions of clarification and more efficiently plan their study activities. Such activities are quite different from passively accepting (yet momentarily actively processing) the particular information that a person or text presents."[20]

Active Learning Tested In The Classroom

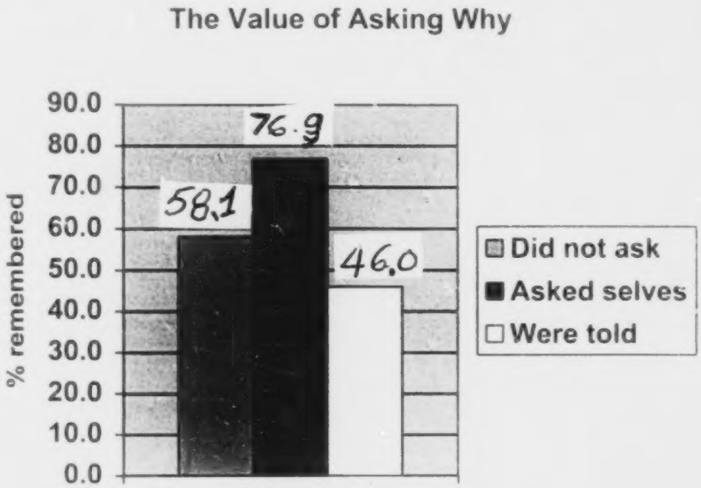
☞ Active learning seems to be a basic principle of memory, but does it actually help in the classroom? Hundreds of studies have been done on the advantages of active learning, including group learning, cooperative learning, and non-lecture classes. A few studies are reported below.

☞ In a review of a learning method where students make up their own main idea questions after reading, middle-school students did an average of 32% better than they had in lecture classes. In these 16 studies, students were actively involved in reading, leading discussions, and asking and answering main idea questions about their reading.[21]

☞ College students in a remedial biology course who listened to a short lecture and then applied what they had learned by working in pairs increased their number of correct answers by 12, but those who learned from lecture only increased by 8.5.[22]

☞ College students who made up their own headings or topic sentences remembered more than students who were given headings or topic sentences for the same reading passage.[23] In another study 6th-grade students who made up their own summaries increased their scores by more than 45% over students who did not make their own summaries. And in another study, junior high school students who made up their own summaries or topic sentences increased their scores by around 25% over students who did not make their own.[24]

College students who were taught to ask themselves why something in a text was so remembered 33% more than students who were not taught. For example, given the sentence, "The dying man used a feather." students might say, "The dying man used a feather to sign his will." Students who were told the connections remembered even less than students who were just asked to remember the short sentences. In other words, giving students the answer got in the way of their learning![25]



Four-year-old children in a similar study showed the same results. They heard stories about different kinds of animals that look the same, such as a caterpillar that looks like a snake. One group of children was asked, "Why would a furry caterpillar want to look like a snake?", and the other group was told that some caterpillars look like snakes so that they will not be eaten. The children who had come up with their own explanations did from 40%-80% better at explaining a similar problem than children who had been told the answers.[26]

Making a picture or cartoon is a good way to learn vocabulary words, but it works better if students make up their own (active) than if the teacher does it for them (passive).[27]

Good college readers actually wrote better summaries when they had to work hard to understand a text. These students included about 50% of the most important points from the text in their summaries when they read very clearly written texts that they did not have to work hard to understand. But they included almost 60% of the most important points when they read poorly written texts that they had to actively try to comprehend (Badly-written text had the opposite effect on poor readers).[28]

People remember better when they are physically involved in learning. Five experiments where people heard words, watched an experimenter do something, or did something themselves, showed that "doing" has a powerful effect on learning. Those who "did" remembered from 1/3 to 2 times more than those who just heard, and they remembered for longer.[29]

Field trips can also increase student learning right after the field trip and later, **if students are actively involved**. One study compared students who:

1. took a field trip and had to do exercises and take notes (active group), or

2. took a field trip where teachers pointed things out and students checked items on list (passive group), or
3. had no field trip.

The actively involved group scored 13% better than the passive group on a test after the field trip and 75% better than the passive group on a test 3 months later.[30]

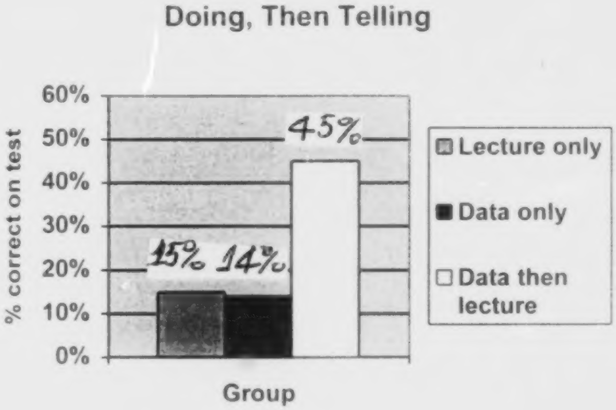
Active learning may also motivate students more. Students who studied a passage in order to teach it (active learning) learned the material 37% better than students who studied to pass a test (passive learning)--37 questions right out of 48 vs. 27 right. Both groups spent the same amount of time studying. The active learning students also said they were more interested, enjoyed learning more, and were more willing to continue learning.[31]

When Does Lecture Work?

Does lecture ever work better than active learning? In an interesting study called "A Time for Telling," an undergraduate psychology class learned about a topic in one of three ways:

1) Reading and summarizing the textbook, then hearing a lecture about various memory experiments (traditional),
2) Looking at the data from the same experiments (inductive), but no lecture, or
3) Looking at the data from the experiments and then hearing a lecture (combination).

All of the students then took a test that asked them to predict the results of a different memory study (a transfer test). Students in the third (combination) group did three times as well (or more) as either of the other groups--looking at the data got them thinking actively, which prepared them for the analysis in the lecture. The lecture helped them organize their observations.[32]



Interestingly, college students who described a hard-to-describe visual event in words (colors, yearbook photos, a videotape) had a worse memory for the event than students who just looked.[33] It seems that people's memory of what they said about some events is stronger than their visual memory.

In addition, students who simply wrote new sentences using vocabulary words did not learn the words well. Students need a variety of types of exercises (which can include writing new sentences) in order to learn and understand new vocabulary words.[34]

Pure discovery learning, where students are set loose to explore without any direction or guidance, does not work very well. Students tend to get distracted and may not notice the most

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important information they need to learn. They learn less, remember less, and do less well on problems that are not just like the ones they solved (they transfer their learning less well). Students who use discovery learning and have clearly defined learning tasks, guidance from a teacher, and practice in doing many different types of problems (guided discovery) do better than students who got lectures. They learn more for understanding and transfer their learning better.[35]

ADULTS

Adult students are used to active learning at work, but they may not be used to it in schools. It may help to explain to students why they are writing letters, doing experiments, taking field trips, or playing educational games rather than listening to a lecture.

Summary

1. Students who are more actively involved in learning remember better, get a deeper understanding, and are better at solving problems.
2. Teachers play a very important role in supporting students during active learning by demonstrating good thinking, asking questions, clarifying ideas, providing more information, and giving feedback.
3. Pure discovery learning without guidance from a teacher does not work well, especially where students have poor background knowledge about the topic.
4. Lecture only works well when students have had some experience actively working with the topic to prepare them for the lecture.

What it means for teachers

Active Learning

Active learning is not the same as hands-on activity. The idea of active learning is that "students need practice in exercising and managing basic cognitive skills,"[36] including:

- recognizing important information,
- organizing that information,
- connecting the information with what the person already knows, and
- being aware of whether information has been recognized, organized, and connected.

Hands-on activities (like traditional science labs) where the teacher tells the students exactly what to do can be just like rote learning--the students do the steps but do not understand why they did them.[37]

Modeling

Before teachers ask students to practice new skills, the teacher should demonstrate the skill. In order to "make thinking visible,"[38] this usually means that the teacher will talk out loud about his or her own thinking process, "First I look at the front cover and think, 'Am I interested in any of these articles?', then I find the table of contents . . . "

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Point Out What To Notice

🔑 Before you read, look at a map or photograph, or do an experiment or hands-on project, point out what you want students to notice, "I want you to look for rust on the steel wool and notice which one rusts faster."

Develop Students' Self-awareness Of Their Own Thinking

🔑 See Fact Sheet 4: Thinking About Thinking for more information.

Ask Questions

🔑 Ask questions that get students to figure things out for themselves, rather than telling them.[39]

Alison King suggests these questions:

"What is a new example of . . .?
How could . . . be used to . . .?
What would happen if . . .?
What are the implications of . . .?
What are the strengths and weaknesses of . . .?
What is . . . analogous to?
What do we already know about. . .?
How does . . . affect . . .?
How does . . . tie in with what we learned before?
Explain why . . .
Explain how. . .
What is the meaning of. . .?
Why is . . . important?
What is the difference between . . . and . . .?
How and . . . and . . . similar?
How does . . . apply to everyday life?
What is the counter-argument for . . . ?
What is the best . . . and why?
What are some possible solutions to the problem of . . .?
Compare . . . and . . . with regard to . . .?
What do you think causes . . .? Why?
Do you agree or disagree with this statement: . . .?
What evidence is there to support your answer?
How do you think . . . would see the issue of . . . ?"[40]

🔑 Provide structure for students to discover things on their own:

- set clearly defined learning tasks ("Figure out which one rusts faster, steel wool with water or steel wool with vinegar.");
- provide guidance ("You need to look at the directions to figure out how much vinegar to use.");

- give practice in doing many different types of problems ("Now that we have done our experiment, let's talk about what we saw and then work on some practice problems.").

Students learn best when the tasks are just challenging enough. Tasks that are too easy do not lead to learning. Tasks that are too hard are frustrating.

🔑 Students who read very slowly will have trouble doing discovery learning where they have to read a lot. Try to provide some of the information on a videotape or audio tape with a book that students can follow while they watch or listen.

🔑 Students who have very little background knowledge will have trouble doing discovery learning that depends on their having background knowledge. Try to provide some of the background knowledge by reading together first or using a videotape, field trip, guest speaker, or some other way of building knowledge before students have to find things out for themselves.

Lesson Ideas

Making Learning Active

✍Replace some lectures and solo studying with discussions, hands-on learning, role plays, simulations, games,[41] or other active learning (see below for a few ideas). For all of these activities it is very important to explain to students how the activity is related to the GED, check in with them as they are learning to make sure they understand the assignment, and give students feedback on their performance.

▪ Grammar:	-proofread letters, flyers, or advertisements
	-take a field trip to a newspaper or magazine office
	-interview a writer about writing
▪ Literature:	-write a poem, play, or story
	-act out a poem or listen to a dramatic reading
	-watch a play or movie
▪ Biology, chemistry, physics:	
	-do a hands-on experiment
	-take a field trip to a science museum or science lab at a university
▪ American history:	-role play an event in American history
	-go to a museum and look at art and objects from a time in history
	-look at original documents from a time in history
▪ Social studies:	-role play a bill going from Congress to the president to the courts
	-hold a school election
▪ Geography:	-make a map or a relief map of your neighborhood, state, or the U.S.
	-take a "virtual field trip" and learn about a new place
▪ Math:	-set up a school store: students order, do sales, inventory, and write reports
	-build a table, bookshelves or some other furniture
	-bake a cake or make something from a recipe
	-use play money, measuring cups or rulers, cards, plastic tiles, and other props for teaching arithmetic.

✍Consider doing some Problem-Based Learning that combines several subjects in a real-life problem-solving project--see Fact Sheet 16.

✍When you do lecture, consider giving students some experience with the information first. For example, students could read an original document from the colonial period before you lecture about colonial history.[42]

✍When you do lecture, also consider giving students a note-taking outline to fill in so that they learn to take organized notes.[43]

NOTES

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Fact Sheet 16: Problem-Based Learning

Principle: Maximize Learning by Starting from Real Problems

> "I often ask the class to generate a list of things that plants need. I had observed that whole-class brainstorming often resulted in a rather predictable and limited list of examples, such as *rain, sun, soil,* and *air,* and I wondered about all the unspoken student ideas that were never shared. However, when I . . . [used] cooperative learning strategies . . . the results were dramatically different. . . .and examples such as *time, oxygen, carbon dioxide, care,* and *space* were included."
> —Robert Fardy, science teacher[1]

Questions for teacher reflection

- Think about one of your favorite learning experiences. Did it start with a lecture or textbook, or did it start with something you wanted to know more about?
- In your own teaching, do you tend to start by presenting information or by asking questions?

These questions got you to think about starting from problems vs. starting from information.

What we know

What Is Problem-Based Learning?

☞ Many educators are trying out relatively long-term, interdisciplinary problems in their classrooms to teach thinking and problem-solving skills.[2] Problem-based learning has been studied in adult education, K-12 classrooms, college classes, and many professional schools (including medicine, business, law, social work, architecture, pharmacy, engineering, and education).[3] Problem-based learning[4] uses:

- real world problems that
- students are interested in and that
- draw on skills and knowledge from several different subjects,
- have no simple answers—students have to explain why they chose their answer, and
- are done by groups of students who work together.

One key part of Problem-based learning is that it **starts from a problem**. In other words, it starts with a complex problem that "create[s] a need to know,"[5] rather than starting from a textbook lesson and then giving problems. Problem-based learning is also different from hands-on learning, which may be spelled out step-by-step for learners,[6] or which may not be connected to classroom learning (e.g., a field trip that is not related to what is being taught in the class).

☞ Some examples of problem-based learning in adult education classrooms are:

- setting up and running a school store, café, catering, or other business;[7]
- publishing a class newspaper or newsletter;
- writing a survey on neighborhood problems, collecting and tabulating answers, and holding a community forum;[8]

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- studying regions of the world and then painting a map of the world on the classroom wall;
- writing a cookbook with family recipes that immigrant students can share with their children;[9]
- illustrating a folktale and presenting it to a class of 8th grade students; and
- taking a "virtual field trip" to learn about American history and geography using the Internet and other sources of information.

Why Problem-Based Learning?

☞Problem-based learning (PBL) is one way to integrate many features of effective learning:[10]

1. **Subject-specific problem solving**—Problem-solving methods depend on the kind of problem that is solved, so realistic problems should be used.[11] (See Fact Sheet 1: Literature is not Science)
2. **Classroom problems that are like real-world problems**—Real-world problems are complex; the problems that students work on in school should be like the ones they are asked to solve outside of the classroom.[12] (See Fact Sheet 2: Making Connections)
3. **Learning for understanding**—In order to solve the problem, students need to learn for understanding, which helps them transfer their knowledge and remember what they have learned.[13] (See Fact Sheet 2: Making Connections)
4. **Confronting misconceptions**—Students usually have misconceptions that can interfere with learning; problems can confront those misconceptions and help students look at things in a new light. (See Fact Sheet 3: Mental Models)
5. **Being aware of one's own thinking**—Students become more aware of their own thinking when they have to justify their decisions.[14] (See Fact Sheet 4: Thinking About Thinking)
6. **Meaningful relationships**—The problem and solutions are meaningfully connected, so they are easier to remember. (See Fact Sheet 8: Long-Term Memory)
7. **Multiple perspectives**—Knowledge is complex, so teachers should get students to look at problems from many perspectives. (See Fact Sheet 13: Critical Thinking)
8. **Active learning**—Learning is an active process, so teachers should get students involved. (See Fact Sheet 15: Active Learning)
9. **Generating explanations**—Students learn better when they have to explain things themselves, so teachers should give them a chance to do this. (See Fact Sheet 15: Active Learning)
10. **Using student interests**—Students are more motivated when they are interested in the topic (See Fact Sheet 17: Supporting Good Thinking)
11. **Learning by doing**—Most people learn by observing others doing tasks and then joining in, whether they are learning to use a copier, cook, purchase wisely, and so on. Problem-based learning can give students the chance to learn by observing and joining in.[15]
12. **Group learning**—Many students learn more effectively in groups.[16] (See below.)

Problem-based learning is not the only way to teach. It does not work for items that must simply be memorized, like spelling. Problems need to be very carefully chosen to fit the knowledge and skills of students. As the National Research Council has noted, "Asking which teaching technique is best is analogous to asking which tool is best--a hammer, a knife, a screwdriver, or pliers. In teaching as in carpentry, the selection of tools depends on the task at hand."[17]

☞The table below contrasts problem-based learning and traditional classrooms:

	Problem-Based Learning	**Traditional Classroom**
Active vs. passive learning	Almost all active learning. Some short strategy instruction may be needed, practice on materials related to the problem.	Mostly passively listening to lectures. Homework is active, but is done alone away from other students and teachers.
Role of prior knowledge	Can build on prior knowledge.	Usually assumes the same knowledge base for all students, and no misconceptions that interfere with learning.
Problem solving	Specific problems are related to a situation that students are interested in.	Many isolated problems at the end of a chapter. Not always clear to students why they need to be able to answer the questions.
Who gives explanations	Students come up with and justify their own explanations. Teacher may help by providing information or sources (such as readings or Internet web addresses)	Generally teacher gives all explanations.
Many perspectives	Can look at one problem from many angles, e.g., a chemical spill problem includes chemistry, public relations (communication), government regulations, and so on.[18]	Usually just one subject, but could include many subjects (e.g., humanities classes that include history/government, geography, literature, art, music)
Complex problems	Problems are real-life and complex, there is not "one right answer." Students have to ask questions and search out more information.	Problems are simple and usually all of the information is given. Sometimes a few "distractors" are added, but not as many as in real-life problems.
Group learning	Most learning is done in groups. Learning is more effective, and real-life social skills are developed.	Most learning is done in large classes (lecture) or alone (homework).
Transfer	Problems bring the real world into the classroom and explicitly apply classroom learning to outside problems.	Material is usually abstract and disconnected from applications. Some lecturers give real-world examples and/or homework.
Self-awareness of own learning	Because students have to explain their reasoning, their ability to monitor their own thinking increases.[19]	Students may never be asked to justify their thinking in lectures (except in e.g., law school).
Independent learning skills	Students learn how to ask questions, research, and solve problems.[20]	Students usually depend on grade to know if they are right. Often does not develop independent learning.

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Problem-Based Learning Students Often Learn Better

☞Problem-based learning is harder to teach than lecture classes; it requires more planning and research and more flexibility from teachers.[21] But several recent studies show that it is at least as effective as or more effective than many teaching methods in several areas.

☞**Learning facts**—Some teachers are afraid that problem-based learning students will not learn facts because they are so busy solving problems. In two studies, problem-based learning students did better on factual tests than students in regular classes;[22] in four studies, problem-based learning students did just as well on factual tests;[23] in two studies, problem-based learning students did worse on factual tests (but better on reasoning tests);[24] and in two studies, problem-based learning students did worse overall[25] (2 better, 6 tied, 2 worse).

☞**Critical thinking**—One study showed how students' thinking actually changed during a problem-based learning meeting, as they discussed the evidence for two different explanations.[26] In another study, problem-based learning students used better thinking (more expert-like thinking) than non-problem-based learning students. PBL students more often started from a hypothesis and saw if the information fit. Non-PBL students more often started from the information and assumed that the first explanation that came to mind had to be the right one. These same PBL students also used multi-step explanations that were about 50% longer than the non-problem-based learning students.[27] Problem-based learning can help students at all levels. In one study, low-skill, average, and high-skill students all improved their use of scale and measurements on drawings of playground equipment they designed.[28]

☞**Memory**—One study showed that 6 months after classes, problem-based learning students remembered up to five times as many facts as non-problem-based learning students.[29]

☞**Planning**—Problem-based learning students can become much better at planning how to solve problems, such as what to do first, recognizing when they need more information, and so on. In one study, students were asked questions about what factors they needed to consider when solving a problem, and why. PBL students got more of these questions correct than non-PBL students.[30]

☞**Better research skills**—Problem-based learning students in two studies used the library more than non-problem-based learning students.[31]

☞**Identifying the problem**—Problem-based learning students can become much better at looking at a messy problem and identifying the central problem that needs to be solved. In one study, problem finding increased from 35% before problem-based learning to 60% afterwards.[32] Defining the problem is a critical thinking skill which can help students on the GED.

☞**Improved attitude**—Students in one problem-based learning math study increased their self-confidence about math, thought math was more useful, were more interested in math, and felt more positive about math challenges than before the unit. Students in regular classes decreased in all four areas (that is, they were less self-confident, etc. at the end of the school year).[33]

☞**Students' awareness of their own thinking**—Several problem-based learning programs are designed to make students more aware of whether they have understood what they read, whether they have answered the question adequately, whether they have good reasons to support their answers, and so on.[34] Some programs do this by having teachers model these kind of questions and then have students discuss their answers, while others use computer programs and e-mail between classrooms.

☞**Multiple solutions**—Students in two problem-based learning studies were better at generating many possible solutions, which is a hallmark of good decision making.[35]

The Ingredients For Successful Problem-Based Learning

☞Just like a discussion, lecture, or any other teaching method, there are some ingredients for successful problem-based learning. Most importantly, the teacher needs to set clear learning goals and guide students' learning along the way:

1. The problem has to be interesting to students.
2. It must be complex, so that there is not an obvious solution, but not so hard that students cannot do it.[36]
3. Students need information that is accessible enough to them. Higher-level students may do their own research, while the teacher may lead lower-level students directly to the best resources.
4. The GED-relevant learning goals of the problem need to be explained to students. For example, in a "virtual road trip," students will learn U.S. geography, history, math (distances, rates, etc.), and map and graph reading skills that can help them pass the GED. The problem also needs to point students toward using those skills.
5. The information that students get must be relevant to the problem (not just "useful information").[37]
6. Problem-solving methods will need to be explained along the way--for example, students should first realize they need to add fractions to move forward on their problem, and then the teacher shows them how to do that.
7. The teacher needs to support students to do the problems, even though they are difficult. This can take the form of suggestions, coaching, questions, hints, resources, etc.
8. The teacher needs to check in with the groups to make sure they are on task and they are not stuck.[38]

1. Interesting Problems

☞Interest in a subject is a powerful motivator for students: in 7 out of 8 studies, students who read about topics that they were interested in improved their reading comprehension more than students who read topics not related to their interests. Problem-based learning programs in professional schools count on students being interested in problems related to their future careers. That is, medical students will be interested in problems built around medical cases where they must put themselves in the shoes of a doctor. In K-12, college, and adult education classrooms, problems need to tap into more general student interests (e.g., adult students who have a life goal of being self-employed will design their own business, elementary school children will design a playhouse and enter a competition where the best design will actually be built).

2. *Complex, Real-World Problems*

SAMPLE:
You are driving from Washington, DC, to visit a relative in another part of the U.S. Using a map and other information, figure out:

1. What route to take;
2. When to tell your relative you will arrive;
3. What cities you will stay in along the way, where you will stay, and how much it will cost; and
4. How much money you need for gas and other driving expenses.

Write a letter home about your trip explaining all of these things.

☞ Problem-based learning lets students practice real-world problems in real-world situations. For example, science students might measure air quality in their school using real scientists' tools to do real scientific thinking.[39] Real-world problems can help organize students' knowledge in useful ways, and it can develop problem-solving skills.[40] Textbook problems often have obvious answers, but real-world problems are messier. There is a lot of information, and there is not one right answer or one right approach.[41]

ADULTS
Problem-based learning may be particularly suited to adults, who (like adolescents) want their learning to be practical and immediately useful. It has been tested extensively in professional schools.

3. *Accessible Information*

SAMPLE:
You have a U.S. road atlas. Your teacher will give you other information you need, or help you find the information, but you need to ask for it and explain how it will help you answer the questions.

☞ For successful problem-based learning, students need information that is accessible enough to them, but should not have all of the information provided from the start. The goal is to get students to figure out what information they need.[42] Higher-level students may do their own research, while the teacher may lead lower-level students directly to the best resources.[43]

4. Learning Goals

> **SAMPLE:**
> Your goal is to:
> - Plan the trip using the fastest route (considering both distance and traffic).
> - Create an accurate budget for the trip.
> - Write a report that someone who is not on the trip with you can understand.

☞A good problem will clearly explain what the product should look like, and why. For example, one science class problem was building a rocket. However, students were not told that the point of the problem was to figure out how to make the rocket go as high as possible. So students did not notice what features (such as a pointed nose cone) made some rockets fly higher than others. They also did not measure how high the rockets flew, but simply watched them launch. Later, the problem was redesigned so that students were told to report what features made the rockets fly higher and also to measure the actual height. Not only did they keep track of features and learn how to use an altimeter, they spontaneously started teaching another class that had made rockets and was simply watching them.[44]

☞The GED-relevant learning goals of the problem also need to be explained to students. For example, in the "virtual road trip" mentioned earlier, students will learn GED geography, history, math, and map and graph reading skills. The problem needs to point students toward using those skills.

5. Information Relevant To The Problem

> **SAMPLE:**
> We will be using road maps and relief maps for this project. Even though your GED textbook has a section on topographical maps, they will not really help us plan this road trip, so we will not be using them.

☞The information that students get must be relevant to the problem (not just "useful information").[45] Teachers need to avoid adding in extra information that they think students should know but that is not relevant to the problem at hand.

6. Need For New Problem-Solving Skills

> **SAMPLE:**
> You already know how to use a city street map. The GED also requires you to read other kinds of maps, like highway maps, historical maps, and so on. We will practice using these kind of maps in our project.

☞Problems need to push students beyond their current understanding and skills, and give them an incentive to learn new skills.[46] Students will probably be tempted to solve the problem using only the skills they already have. The problem needs to be structured so that they see the need for new skills.

7. *Supporting Student Learning*

SAMPLE:
Tell me why you decided to go through Canada on your way to Michigan. Are there other ways you can go? What is the price of gas in Canada? Will that affect your route?

☞ Students will need support from teachers in the form of suggestions, coaching, questions, hints, resources, modeling or demonstrating solutions, leading discussions, and so on. The teacher in a problem-based learning classroom does not sit in the corner. The teacher sets up a situation that will help students learn the best, and then helps them learn as much as they can from their problem solving.[47] For example, the teacher might ask, "Have you considered all of the possibilities?" rather than "Have you considered x?"[48]

☞ Teacher feedback during group work is a critical part of problem-based learning.[49] It is the teacher's responsibility to step in when students are falling back on prior knowledge, not thinking through their answers to the problem, not presenting evidence for their answers, and so on. (See Fact Sheet 14: Critical Thinking for more information.)

8. *Managing Groups*

☞ More than 100 studies show that students learn better in groups, as long as there are both individual and group rewards.[50] Groups work especially well when they know what they are supposed to do as a group (for example, they are told to take turns reading and asking questions). In one study, pairs who were told how to study scored an average of 84%. Solo students following the same directions scored only 69%.[51] One reason is that members of groups usually take on roles of idea generators, critics, and moderators. Each role is an important part of any person's problem-solving ability.[52] Another reason is that more advanced students who do more explaining in groups will gain a lot more than students who have things explained to them.[53]

☞ Even students who do not say much learn well in groups,[54] and team work can also develop social skills that students will need at work. The teacher needs to check in with the groups to make sure they are working on the problem and they are not stuck.

Summary

1. Problem-based learning uses real-life, complex problems to motivate students to learn new facts and skills.
2. PBL uses active group learning and a multi-disciplinary approach.
3. In most studies, PBL students learn facts as well as students in traditional classes, and improve their problem-solving skills and attitudes more than those students.
4. Teachers need to prepare more for PBL classes than for traditional classes.
5. Teachers need to choose problems that students already know something about so that students can build on that knowledge.
6. Teachers need to provide the right amount of information about the topic to students.

Teachers may need to provide all of the information to beginners; more skilled students may do their own research.

7. The teacher needs to develop clear learning goals and hold students accountable to them.
8. Problems need to be complex enough that they push students to learn and use new strategies.
9. Students will need support from teachers in the form of suggestions, coaching, questions, hints, resources, modeling or demonstrating solutions, and leading discussions.

What it means for teachers

Choosing Problems For Problem-Based Learning

🔑 Be sure your problem-based learning problems include an appropriate level of

- interest,
- available information,
- use of several subjects, and
- problem-solving skills

for your students.

The Teacher's Role

🔑 The teacher's role is to:

- choose an appropriate question (see below)
- provide readings or help students to find their own
- teach students specific skills that they ask for (e.g., map reading for a problem involving maps)
- check in with groups to make sure they are on task, understand the question, etc.
- ask lots of questions while the groups are working
- facilitate student presentations and the questions that follow
- provide feedback to students after their presentations and revisions

Steps in Problem-Based Learning

1. Explain what the problem is.
2. Explain the learning goals of the problem.
3. Explain the process:
   a. Read the problem
   b. Identify any more information you need
   c. Teacher checks in with each group
   d. Get and read all information
   e. Work on the problem
   f. Prepare a report or product (e.g., diagrams, models, presentation, etc.)
   g. Present the report or product to a judge or class, who will ask questions
   h. The teacher gives feedback privately
   i. Revise the report or product.
4. Divide the class into groups and assign work.

5. Check in with groups--ask what students are doing, ask why questions (see page 76 and Fact Sheet 15, pages 6-7), point students in productive directions.
6. Provide additional information or show students how to get information (depending on the level of the group).
7. Students prepare and present their report or product (often to an outside judge, panel, or competition).[55]
8. Students take questions and comments from the audience or class.
9. Students revise their report or product based on the questions and comments.

Lesson Ideas

Choosing Problems for PBL

> "Dear Students,
>
> There is a proposed bond issue for renovations to the water treatment plant, and town officials feel the citizens of Hampton need to be better informed about the current water treatment facility, proposed changes, and the expected benefits and costs. Unfortunately, many people in Hampton are unfamiliar with the important work that our wastewater treatment department does. Town officials would like to hire a marketing firm to help educate voters in Hampton about this water treatment plant. Since you have been studying water pollution and its effects on our environment, I thought you would be well qualified to act as designers for this information campaign to educate Hampton's citizens."[56]—A PBL assignment by Rick Gordon

✍Ideally, problem-based learning problems arise out of student interests and ideas. But since most students are not aware in much detail of what skills and knowledge they need to reach their goals, teachers have an important role in defining problems. To be successful, problems need to also include several topics, present a challenging level of information and problem-solving skills, etc. (see above). In addition to the problems mentioned on page 1, here are some other ideas:

- Consider any ethical problem faced by society using the PBL format:
  - the right to die
  - the minimum wage and unemployment
  - cleanup of toxic wastes
  - the building of a factory, sewage treatment plant, etc. in a particular neighborhood
  - design a plan to help the elderly or children, or immigrants, or some other group in this community, and so on[57]
- Make a quilt, mural, or other artwork that reflects some part of students' lives or history.
- Bring in problems from your work or home (such as planning a project or conference, planning and making a piece of furniture or draperies, planning a family reunion, and so on).
- Look on the Internet for successful projects that have been tested in the classroom (some are costly):

  The Jasper problem-solving series:

  http://peabody.vanderbilt.edu/ctrs/ltc/Resources/products.html

  Technical Education Research Centers (TERC--lists more than 40 projects):

  http://www.terc.edu/projects/projects.html

  Illinois Math and Science Academy, Center for Problem-Based Learning (includes a link to the Problem-Based Learning Network [PBL Net])

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http://www.imsa.edu/team/cpbl/cpbl.html
Little Planet children's problem-based learning:
http://www.littleplanet.com

NOTES

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Fact Sheet 17: Supporting Good Thinking

Principle: Motivation Comes from Classrooms, Not Just Teachers

> "I think I can, I think I can . . . .
> I know I can, I know I can!"--*The Little Engine That Could.*[1]

Questions for teacher reflection

- Do you think motivation leads to learning? How?
- What is your model for how to motivate students?
- How does your model affect your teaching? That is, what does it suggest you do in your teaching or avoid in your classroom?

What we know

What Engages Students?

☞ Why is it that some students read a lot, use good reading comprehension strategies, read for understanding, and like reading, while other students avoid reading, use few strategies, read to get through the passage, and do not like reading?[2] The simple answer that the first group is good at reading does not seem to be enough—students can know how to use good reading strategies (like using the dictionary) but not use them.[3] Students can read a textbook to get through it, but then go home and read a story with a goal of deep understanding.[4]

☞ A lot of research has been done on the ingredients of good thinking--noticing patterns, background knowledge, problem-solving strategies, practicing skills until they are automatic, and so on. But what can teachers do to encourage students to use these thinking skills, get hooked on reading, and support good thinking? How do students go from "I think I can" to "I know I can"? Clearly good thinking involves more than knowing how to do schoolwork, motivation is a powerful part of learning.[5] Researchers have been focusing more on these questions in the last ten years than they had in the past. John Guthrie and Allan Wigfield have reviewed many of these studies and identified nine things that seem to make the most difference in supporting student learning:[6]

1. Student **learning for understanding**[7] (not just for getting the question right, making the teacher happy, or getting a good test score).
2. **Topics that students are interested in**[8] (such as job-related materials, the GED, computers, sports, medicine, and so on)--rather than only topics dictated by the teacher or curriculum.
3. **Real-world learning** that is relevant to students' life experiences (such as hands-on science, writing a business letter that the student will send, and so on)--rather than worksheets or tasks that are seen as "busywork."[9]

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4. **Real choices in learning,**[10] such as a choice of books, a choice of topics, or a choice of field trips or hands-on learning.
5. **Learning reading comprehension strategies**--Step-by-step learning, practice, and feedback on reading comprehension strategies like summarizing, asking questions, and prediction.[11]
6. **Working with other students to learn**.[12]
7. **Measuring student progress**--Evaluation that measures understanding and knowledge, which includes both tests and work samples.[13]
8. **Involved teachers**--Teachers who know students individually and show they want them to progress, not just show care for them personally.[14]
9. **Rewards that are related to learning for understanding**[15] (not just the right answer), **using good strategies**[16] (not just using ones the student is comfortable with), **and making real progress**[17] (not just for showing up, doing exercises, or participating).

The learning environment that students grew up in[18] and how they were rewarded in school[19] will also affect their motivation in our classrooms.

☞ These nine items are based on looking at classrooms where students are excited about learning and learn more than students who are not excited. They are not based on teachers' instincts about what works, although many teachers' instincts are validated by the research. However, several studies have found that teachers' instincts can backfire. For example, students who get gold stars for reading later read less when there are not rewards.[20] They are being trained to read for gold stars, not to read for fun or escape, to expand their horizons, or to learn.

These nine factors can lead students to feel:

- "I know how to learn."[21]
- "My success is due to my efforts, not to luck, favoritism, or simply showing up."[22] and
- "I want to learn more."[23]

Notice that the way we usually talk about motivation is not mentioned here: "I feel good about myself." For example, in one study students were taught either 1) no reading strategies, 2) reading strategies, or 3) both strategies and how to see that their success came from their efforts (attribution). Here were the results:[24]

	Strategy use up	Reading comprehension up	Self-esteem up
1) not taught strategies	No	No	No
2) taught strategies only	Yes	No	No
3) taught both strategies and attribution	Yes	Yes	No

Notice that general self-esteem, or "I feel good about myself" was not nearly as important as knowing how to do the work (learning strategies) and seeing the connections between using the strategies and being successful. These led to a feeling of "I have the skills that help me learn."

ADULTS

Because many adults enter programs with low self-esteem, there is a temptation to "boost their confidence" with easy assignments and praise. Unfortunately, this can lead students to think they are stupid, otherwise why would we give them easy assignments.

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1. Student Learning For Understanding

☞ Students who read to get to the end of the passage or do problems just to get the question right (whether they understand it or not) tend to do poorly. They tend to memorize and guess rather than making sense out of what they read and understanding problems.[25] Students who want to understand what they read and understand problems do better in school.[26] These are students who agree with statements like, "Understanding this subject is important to me."[27] Unfortunately, workbooks with "one right answer" exercises, rote drills, and multiple-choice tests can encourage students to think shallowly. Meaningful repetition, discussions, and exercises where students have to explain what they think and why can help students see the goal of learning as understanding. Students who learn for understanding use more reading strategies than rote learners,[28] and they keep trying when learning is hard more than rote learners.[29]

Students who want to understand also react better to tough assignments than students who just want to get the right answer.[30]

Student learns for understanding	Easy assignment	Uses good strategies and gets good answers.
	Hard assignment	Likes the challenge, uses good strategies, and gets good answers.
Student just wants to get the right answer	Easy assignment	Likes the opportunity to show how well he/she can perform for others—uses good strategies and gets good answers.
	Hard assignment	Sees the assignment as a threat to looking good, acts helpless, fails to use the good strategies he/she knows, gives poor answers.

ADULTS

Because adults come to school for their own reasons (they are self-motivated), we may mistakenly think that they do not have a "right answer" approach to learning. Yet most teachers have worked with a student who asks after every question, "Teacher, did I get it right?"

2. Topics That Students Are Interested In

ADULTS

☞ Adult students' reading comprehension over the term improves more when they read about topics they are interested in (such as career interests or health topics) than students who read about "general" topics.[31] Students also have better comprehension because they have more background knowledge (including vocabulary).[32] Adults who read about topics they are interested in also read more,[33] which makes them better readers.[34] ABE students who had more individualized lessons improved their reading more than students who did not have individualized lessons.[35]

☞ One challenge in GED classes is balancing student interests with GED content (See Fact Sheet 12: The Importance of Teaching Content). Teachers may need to alternate topics that are interesting to students with GED topics, or figure out how to incorporate GED content into these topics (such as decimal word problems based on sports statistics or teaching human biology through medical examples for students interested in health careers).[36]

☞ Personal interest is different from passages that are written in an interesting way (exciting, lively, dramatic, and so on). Students may like lively texts (certainly more than dull texts!), but they can be distracted from the main point. For example, students who read about Horatio Nelson and his role in the Battle of Trafalgar remembered 34-47% more unimportant but exciting details (how he lost his arm in battle) than important but unexciting details (his valor in battle and navigational skills).[37] So interesting details need to be used strategically in texts to reinforce the main point.[38]

3. *Real-World Topics And Assignments*

☞ Students learn better when they believe that the assignments they do are interesting and important (can be useful to them someday),[39] rather than shool-type worksheets or "busywork." The importance of using real-world topics is explained in Fact Sheet 16: Problem-Based Learning. As with topics that students are interested in, real-world assignments need to be related to or balanced with GED content. For example, a GED chemistry class that bakes a cake in order to understand acids and bases can miss the chemistry lesson and just remember the cake. (See Fact Sheet 2: Making Connections). Students may enjoy the activity but later see no progress in their learning, or they may resent the activity as a waste of their time. Both groups are likely to drop out, in my experience. Likewise, a student may think that learning about buying a home is valuable, but may not see the relationship to passing the GED (reading comprehension, math, economics, and so on).

4. *Real Choices In Learning*

☞ Giving students choices helps them feel some control over their learning.[40] For example, the entire GED social studies test cannot be covered in one semester. Students can have the choice of focusing on history, geography and maps, economics and graphs, or psychology for the term. Learning choices need to be appropriate for students' skills. For example, a lower-level student could have the choice of reading *News for You*, a pre-GED social studies text, or an easy-to-read historical novel (like *Johnny Tremain*) for learning about government. But giving the student a "choice" of a best-seller that is far above his reading skills is a demotivating set-up (without the support of a taped version or reading along while a tutor reads aloud). All of the choices need to include real content and a chance to practice real skills, which means that choosing materials is a very important role for teachers. Choices also give students a chance to tell you what real-world topics they are interested in.

☞ Choices need to be backed up with support from teachers. For example, a student who chooses a book about a topic she is fascinated by, but that has relatively difficult vocabulary, will need help from the teacher to understand that vocabulary. Choices get students "hooked" on reading, which leads them to use better reading strategies and improves their reading.[41]

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5. *Learning Reading Comprehension Strategies*

☞ For students to feel competent at reading, they need real reading comprehension skills.[42] The steps laid out on pages 39-40 are a proven method for teaching reading strategies like summarizing and asking questions, which really improve students' reading comprehension. Better comprehension leads to more reading, which raises background knowledge[43] and improves memory,[44] problem-solving,[45] and improves reading again.[46] Teaching reading strategies also leads to better understanding (rather than rote learning), which is itself motivating.[47]

6. *Group Learning*

☞ The benefits of group learning are also explained in Fact Sheet 16: Problem-Based Learning. A recent study also showed that adult literacy students dropped out much less often from small group classes than from either large classes or one-on-one tutoring.[48] Presumably this is because students form friendships in small group classes that give them the extra push needed to keep coming back to class.

7. *Evaluation And Tests That Measure Both Understanding And Knowledge*

☞ Teaching for understanding and then testing only for rote learning is demoralizing. Measuring both students' understanding and knowledge can support learning for understanding, real-world learning, strategy instruction, and rewards for understanding.[49] Standardized tests are important for funding, accountability, and for students to see their own progress in terms that they are familiar with. Progress in students' actual work is important to measure understanding and progress in real-world skills. This can include writing samples, projects, worked-out problems, and so on. Progress should be measured in concrete ways so that students can see it. For example, you can use the GED essay scoring guide to show progress that is different from increases in multiple-choice grammar or proofreading tests.

8. *Teachers Who Show They Care About Student Learning*

☞ Clearly a teacher who does not bother to learn students' names or interests or who is not interested in students as individuals will not inspire them. When students think that teachers care about their progress and give students some control over their learning, students learn better.[50] Showing that you care about student learning is different from showing that you care about students personally. One study of 6 pre-GED classes showed that the teachers who insisted that students work and showed they cared by identifying specific skills students needed to work on got better results and better attendance than teachers who took an interest in students' personal lives and had a friendly rapport but did not insist on homework, practice, and hard work.[51]

9. *Rewards For Understanding, Using Strategies, And Progress*

☞ Rewards need to be related to learning for understanding (not just the right answer), using good strategies (not just using ones the student is comfortable with), and making real progress (not just for showing up, doing exercises, or participating).

☞ Ironically, praising students can sometimes interfere with learning (even if the student likes and wants the praise).[52] Of course, this does not mean that criticism should replace praise or that we should not create a safe, welcoming environment! But many students believe that they will learn just by coming to class. (They think they will absorb knowledge.) And we often praise students just for coming to class, since they had to overcome so many obstacles just to be there. But this can reinforce students' idea that learning "just happens" and that they do not have to take an active role in their own learning--by struggling with difficult skills, asking questions, considering feedback, practicing in class, and doing homework.

☞ Praise for participating can also backfire when students fall back on the knowledge and strategies they already have and do not challenge themselves to learn and use new skills. For example, praising a student for participating when she uses tick marks for multiplication (5 x 3 = 𝍸 𝍸 𝍸) will not encourage the student to memorize the multiplication facts she needs to succeed.

☞ Schools have learned the hard way that students' self-esteem is based on their real learning[53] that comes from hard work,[54] not simply from giving positive messages and avoiding personal attacks. The students with the strongest feelings of "I know that I will be able to learn the material for this class"[55] are the ones who are taught the skills they need and have proven to themselves that their success in school comes from their hard work, not from luck,[56] pleasing the teacher,[57] or going through the motions of school without effort. In other words, feeling competent[58] comes from success, not from being told you are competent. "I believe you can work hard and learn this," is a different message from "You can (already) do this."

Perhaps a personal example may help to illustrate these items. I started playing the violin at age 30, so I do not learn it as quickly as I do most things in my life, and it can be frustrating. In my own violin lessons, my teacher motivates me by:

1. Learning for understanding—My goal is to make the pieces sound musical, not just to play the notes. This makes me pay attention to how the piece sounds, not just where to put my fingers.
2. Topics that students are interested in—I choose music that I am interested in, which helps me be patient when it takes a long time to learn the piece (see choice below).
3. Real-world assignments—I play real music, not just studies (which tend to be unmusical). I play pieces that other violinists know and that are part of "real world" violin playing.
4. Real choices in learning—I get to choose the pieces I play. My teacher will not let me choose a piece that is too easy or too hard, but I do have a choice among various pieces that will teach me both music (content) and technique (skills). I play pieces I enjoy, so I practice more and work harder than if I were playing pieces my teacher enjoyed, but I did not.
5. Strategies—Before I use a new technique, my teacher shows me how to do it. Since I have been taught the skill directly, I am confident that I can master it.
6. Group learning—Although I take private lessons, I also play in group recitals, and I always learn a lot from watching my fellow students and giving and getting feedback from them.

7. Evaluation that measures both understanding and knowledge—My teacher gives me comments on my playing, both for how musical it sounds and for technique. She evaluates me on my musical goals, not just getting the notes right (although she does care about that, too). I know that my goal of sounding musical is taken seriously because I am evaluated on it.
8. Teachers who show they care about student learning—My teacher asks me how things are going, but she focuses on my practicing. She expects me to make progress every week and holds me to high standards. This makes me want to practice because I know that something is expected of me.
9. Rewards for understanding—My teacher rewards me for improvements in my skill (not just for coming to lessons) and relates my progress to my practicing. This also makes me want to practice because I see that I get better because of practicing, not because I was "born musical" or because time has passed.

Adult Classrooms Now

ADULTS

These ingredients for getting students excited about reading are a very different way of looking at motivation than we often do in adult education. In my experience,

- we think of motivation as caring about students and using interesting topics
- we think we use learning for understanding and rewards for understanding, using good strategies, and making real progress more than we actually do.
- we talk about making real-world connections, giving students choices, using group learning, and evaluating student work, but not many programs do.[59]
- we mostly avoid directly teaching strategies like summarizing or asking questions because we either think it has to be done in a rote way (and will therefore bore and scare off students) or we think it will not make a difference.

☞ The nine items discussed above are a much richer way of looking at motivating students than just welcoming and praising them. These nine items, taken together, also explain why students who enjoy class but do not increase their test scores or see concrete learning usually drop out. It is real progress that makes students feel competent,[60] not being told they are competent (especially if they do not already have the skills).

Summary

Real motivation is built by:

1. Student learning for understanding (not just for getting the question right, making the teacher happy, or getting a good test score) is motivating.
2. Topics that students are interested in (such as job-related materials, the GED, computers, sports, medicine, and so on)--rather than only topics dictated by the teacher or curriculum.
3. Real-world learning that is relevant to students' life experiences (such as hands-on science, writing a business letter that the student will send, and so on)--rather than worksheets or tasks that are seen as "busywork."
4. Real choices in learning, such as a choice of books, a choice of topics, or a choice of field trips or hands-on learning.
5. Learning reading comprehension strategies--Step-by-step learning, practice, and feedback on reading comprehension strategies like summarizing, asking questions, and prediction.
6. Working with other students to learn.
7. Measuring student progress--Evaluation that measures understanding and knowledge, which includes both tests and work samples.
8. Involved teachers--Teachers who know students individually and show they want them to progress, not just show care for them personally.
9. Rewards that are related to learning for understanding (not just the right answer), using good strategies (not just using ones the student is comfortable with), and making real progress (not just for showing up, doing exercises, or participating).

What it means for teachers

A Broader Way Of Looking At Motivation

To really motivate students:

1. Use discussion, why questions, and meaningful practice more than rote drill and multiple choice tests (See Fact Sheet 2).
2. Ask students about their interests, and develop materials that fit into the GED content and problem-solving skills (See Fact Sheet 2).
3. Bring the real world into the classroom, and explain the connections with school learning and GED skills (See Fact Sheet 2, 15, 16).
4. Give real choices of reading, assignments, topics, etc. Be sure all assignments combine real content and real skills (See Fact Sheet 1, 12).
5. Teach students the reading comprehension strategies they need to read well (See Fact Sheet 4).
6. Teach students in small groups (See Fact Sheet 16).
7. Evaluate students using both knowledge tests and real work that shows understanding.
8. Get to know students and show that you care about their learning (not just about them).
9. Give sincere praise for learning and show students how learning is due to their efforts (not pleasing you, luck, or some unknown source).

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Lesson Ideas

Interests And Real-World Tasks

✍Survey your students about their interests and educational and career goals. Develop units that use topics and assignments that are interesting and valuable to students to teach GED content and skills. For example, a student who has a dream of running his own business can learn writing and proofreading by writing a business plan. He can learn GED math by figuring out costs, profits, sales, loans, and other calculations necessary to run the business, and so on.

Evaluation That Measures Both Understanding And Knowledge

✍Use real-world problems as well as multiple-choice tests to measure how well students have learned a unit. For example, students could double or triple a recipe to show that they understand how to multiply fractions.

Group Learning

✍Pair up two classes which will each learn about a topic and then teach each other about it. For example, one class could learn about the history of several countries in West Africa, and the other class could learn about the products and economies of those countries.

NOTES

Most of the research for this Fact Sheet was identified by the members of John T. Guthrie's Spring, 1999 Cognitive Bases of Instruction (EDHD 692) class at the University of Maryland, College Park, to whom I am deeply indebted.

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Fact Sheet 18: Adult Learning—A Summary

Principle: Adults Show The Same Patterns Of Learning As Children, But Very Few Studies Have Been Done

> "I learned many things from the Conference, especially the fact that we are all in the same boat: (a) we do not really know how adults learn."— Roger Díaz de Cossío, National Institute of Adult Education, Mexico, reflecting on the first International Conference on How Adults Learn, held in April 1998.[1]

Questions for teacher reflection

- Do you think that adults learn the same as children or differently? How do you think their learning is the same or different?
- Do you think that adults learn to read the same as children or differently? How do you think their learning to read is the same or different?
- Why do you think so little research has been done on adult learning?

What we know

What Do We Know About Adult Learning?

☞ This fact sheet summarizes information from all of the fact sheets about how different aspects of learning appear in adults. Few of these issues have been tested with adults, so they need to be tested before we can be sure of the conclusions.

Very Little Research Has Been Done On Adult Literacy Students

☞ Most research on "adult" thinking has been done with college students. Very little research has been done on either a) the thinking-skill levels of adults in literacy programs or b) how their thinking develops. (See Fact Sheet 9: How Thinking Develops, Part 1—General and School-Based Development.)

Adult Skills Are More Uneven Than Children's Skills

☞ Adults' skills tend to be more uneven than children's. While we do not expect a second-grade child's reading and math scores to be very far apart, this is common in adults. One reason may be that adults have had more time to improve the skills they are good at, while the skills they are not good at have stagnated. For example, people who read a lot continue to improve their vocabulary and knowledge of the world even after school; those who do not read do not improve those skills.[2]

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Ideas That Interfere With Learning

Low-Level Adult Readers Do Not Read For Meaning

☞ Low-level adult readers and poor child readers both say that the point of reading is to "read the words well off the page." In other words, they do not see the point of reading as learning something, getting needed information, or understanding it, but just saying the words. Most reading specialists agree that beginning reading should mostly, but not entirely, focus on decoding words. Once decoding is quick, most reading needs to focus more on meaning. (See Fact Sheet 5: Getting Information Into Memory.)

Adults May Have More Entrenched Mental Models

☞ Our adult students have had a lot of time to build mental models that do not work well for them at school. They may be quite attached to their mental models, even if these models do not help them solve school problems well. For example, students may believe that the GED tests their knowledge of their own worlds and of their common sense. In fact, the GED is more a test of their ability to distance themselves from what they know and to use points of view they may disagree with.[3] (See Fact Sheet 3: Mental Models.)

Adults Have Had A Long Time To Decide That Certain Topics Are Hard To Learn

☞ Adults have had a long time to decide whether certain topics are easy to learn or hard to learn. These ideas may be more entrenched in adult students than in children, and harder to change. (See Fact Sheet 4: Thinking About Thinking.)

Adults May Have Poor Memory Strategies

☞ Adult students may think that repeating something over and over again is a good way to learn it. In fact, this is a good strategy for remembering what to pick up at the grocery store, as long as you keep repeating it. But as soon as you stop saying it, you are likely to forget the information.[4] So repeating things over and over again is good for short-term memory, but not for long-term learning. (See Fact Sheet 7: Working Memory and Learning.)

Adults May Have Mistaken Ideas About Learning That Interfere With Learning

☞ Most adults who we work with probably went to schools that emphasized fact memorization, not learning for understanding or critical thinking. Not surprisingly, students will have ideas about what learning is and what school is that can interfere with learning for understanding. (See Fact Sheet 5: Getting Information Into Memory.)

Adults May Have Mistaken Ideas About Memory That Interfere With Learning

☞ Adults may have mistaken ideas about memory (such as the sponge model—soak up information until your mind is full) that can get in the way of their using the best ways of learning. Adults may also think they cannot remember as well as children can (even though the opposite is sometimes true). (See Fact Sheet 6: Memory and Learning.)

Adults May Think That Learning Should Be Effortless

☞ Adults may expect learning to come effortlessly—they may forget how hard they worked as children to learn new things, or they may think that remembering school subjects is like remembering the movie they saw the night before—effortless. I have found that it helps students to explain to them that what they are learning will take a lot of effort at first, but eventually it will become automatic as it is for us, their teachers. (See Fact Sheet 8: Long-Term Memory and Learning.)

Adult Students May Not Be Used To Actively Participating At School

☞ Adult students are used to active learning at work, but they may not be used to it in schools. It may help to explain to students why they are writing letters, doing experiments, taking field trips, or playing educational games rather than listening to a lecture. (See Fact Sheet 15: Active Learning—A Summary.)

Adults Have Had Their Misconceptions For Longer, And May Not See Them As Dysfunctional

☞ Adults who have misconceptions (e.g., seasons change because of the Earth's orbit) have had them for a long time. So these misconceptions may be harder to change and may be more of an obstacle to learning for adults.[5] (See Fact Sheet 11: How Thinking Develops, Part 3—Experience Makes Learning Different for Adults.)

Adults May Have Been Using Ineffective Strategies For Years

☞ Adult students may also have been using less effective problem-solving **strategies** for years.[6] For example, a student who guesses words and is not comfortable sounding out words may have been doing this for 30 years! Adults may be more comfortable with less effective strategies (like guessing words), and less comfortable with better strategies (like sounding out words), than children at the same reading level. (See Fact Sheet 11: How Thinking Develops, Part 3—Experience Makes Learning Different for Adults.)

Memory

Adults Have A Fully Developed Working Memory

☞ Adults' working memory is larger than children's. This may be because children have not developed as much of a sense of the patterns of English, including how common words are.[7] Unlike long-term memory, the size of short-term memory does not depend on background knowledge. (See Fact Sheet 7: Working Memory and Learning.)

Thinking Continues To Develop Throughout Life

Wisdom Peaks In The 40s And 50s, School-Type Problem Solving In The 30s

☞ Adults generally feel they have become wiser during their adult years.[8] This practical learning tends to be "how-to" skills, such as how to figure out which bus to take or how to communicate effectively with a supervisor.[9] This kind of learning peaks between age 40 and 59, unlike school-type problem solving, which peaks in the mid-30s.[10] Practical learning includes less fact learning than is typical of school subjects; practical skills also depend on a small knowledge base, unlike school subjects.[11] The workplace is an important place where adults develop reading skills,[12] although again the reading tends to be "how-to" reading, not school-type fact-based reading.[13] (See Fact Sheet 11: How Thinking Develops, Part 3—Experience Makes Learning Different for Adults.)

Even The Lowest-Skilled Adult Learners Have Many Thinking Skills

☞ Adult students who are not developmentally disabled will all have many language, memory, time and thinking skills. Even the lowest-skilled adults have made enormous strides in their thinking since infancy. (See Fact Sheet 9: How Thinking Develops, Part 1—General and School-Based Development.)

Everyone's Thinking Develops Throughout Life

☞ Even among college-educated adults, thinking normally continues to develop through adulthood.[14] For example, people do not totally understand that all interpretations reflect a particular understanding of the world, that there are no "objective" opinions, until college age or older (if ever).[15] Awareness of one's own thinking and learning develops throughout adulthood.[16] There is limited evidence that this self-awareness can be taught directly.[17] (See Fact Sheet 9: How Thinking Develops, Part 1—General and School-Based Development.)

Adult Literacy Students' Reasoning May Be More Uneven Than Children's

☞ For example, an adult student who reads at the 5th grade level and who has trouble drawing logical conclusions from a workbook about the human body can still draw logical conclusions about basketball, his favorite hobby. (See Fact Sheet 9: How Thinking Develops, Part 1—General and School-Based Development.)

Children's Thinking Is Better, And Adults' Thinking Is Worse, Than Was Thought

☞ In general, researchers are finding that children's thinking is more competent than had been thought, but also that adults' thinking is less competent than had been thought.[18] For example, two-year-old children can use a scale model to find a toy (more competent) while most adults fail at logic problems set in unfamiliar situations (less competent). (See Fact Sheet 9: How Thinking Develops, Part 1—General and School-Based Development.)

Strategies And Content Knowledge Can Be Taught

☞ Problem-solving strategies and content knowledge are important engines of development for teachers of adults, because they do not develop naturally. Strategies and content knowledge can be effectively taught, and they should be taught together. (See Fact Sheet 10: How Thinking Develops, Part 2—Changes in Strategies.)

Most Adults Sometimes Have Trouble With Abstract Thinking

☞ Most adults, even those with a college education, have trouble with abstract thinking in some settings. A large body of research on thinking errors among adults shows how often people use faulty reasoning on unfamiliar or emotionally-charged topics.[19] (See Fact Sheet 10: How Thinking Develops, Part 2—Changes in Strategies.)

Most Learners Start With A "Get The Answer" Approach And Only Later Try To Understand

☞ The pattern of first trying to give the right answer and only later trying to understand why a strategy works is common in children, and in my experience, in adults too.[20] (See Fact Sheet 10: How Thinking Develops, Part 2—Changes in Strategies.)

Children's Misconceptions Persist In Adults And Interfere With Learning

☞ There is a set of common misconceptions among children that probably persists in many adult students. These include misunderstandings of the shape of the Earth, how objects move when they are thrown forward and dropped at the same time, and applying whole-number principles to decimals (thinking that .268 must be bigger than .45 because 268 is bigger than 45).[21] (See Fact Sheet 10: How Thinking Develops, Part 2—Changes in Strategies.)

More Active, Involved Students Get More Attention And Develop More

☞ More active, involved children are exposed to more varied environments, which leads to more developed thinking.[22] Level of involvement may affect adult literacy students too—more active, involved students may get more teacher attention. (See Fact Sheet 10: How Thinking Develops, Part 2—Changes in Strategies.)

Adult Experience

Using Adult Experiences To Teach With Analogies

☞ Adults have some more experiences to make analogies from than children do. For example, they may know about car engines, electricity, work, city politics, and so on. Keep in mind, though, that many adult literacy students have a very narrow range of experiences. For example, they may ride the bus but not the subway. (See Fact Sheet 2: Making Connections.)

Adult Literacy Students' Narrow Knowledge Base Can Make It Harder For Them To Learn

☞ Although adults clearly have more life experience than children, many adult literacy students do not have a large base of factual knowledge to relate new information to. For example, if they do not know anything about garden vegetables, we cannot help them learn about trees by relating this new information to vegetables. (See Fact Sheet 8: Long-Term Memory and Learning.)

Life Experience May Not Lead To Large Vocabularies

☞ Even though adults have been alive longer than children, they may have had "one year repeated forty times" rather than 40 years' experience.[23] Despite their family, job, and other adult experiences, many adult literacy students have small vocabularies (about 15% larger than a 5th grader's vocabulary).[24] Children's vocabularies after about 5th grade grow mostly from what they read, not from hearing new words,[25] but adult literacy students have never read much. Basically, adult literacy students use the same small spoken vocabulary as when they were 11 or 12. (See Fact Sheet 11: How Thinking Develops, Part 3—Experience Makes Learning Different for Adults.)

Life Experience Is The Basis For Some Better Comprehension, But Only In Familiar Topics

☞ There are a few ways that adult students' thinking is different from children's thinking even at the same level of educational skills. These differences in memory, interests, life experience, and background knowledge[26] (including social relationships and multiple points of view) give adult literacy students some basis for understanding more sophisticated reading materials than children can.[27] When low-literate adults read about unfamiliar topics, they perform worse than children who are reading at the same reading level.[28] In a study where adults and children listened and read about Roland and Charlemagne, 5th grade children remembered as much as adults who tested at the 8th grade level. (See Fact Sheet 11: How Thinking Develops, Part 3—Experience Makes Learning Different for Adults.)

Most Adults Are Expert At Something

☞ Our adult students are probably all expert at something (perhaps cooking, sports knowledge, or living on a tight budget). We can use this expertise to help students understand what being an expert at school subjects is like. (See Fact Sheet 13: What Does Good Thinking Look Like—A Summary.)

Adult Literacy Students Make The Same Kinds of Thinking Mistakes As Everyone Else

☞ But adult literacy students' lack of background knowledge makes them prone to thinking mistakes in areas that are familiar to more educated groups, especially belief bias, the availability heuristic, and confirmation bias. (See Fact Sheet 14: Critical Thinking.)

Motivating Adults

Problem-Based Learning May Be Particularly Suited To Adults

☞ Problem-based learning may be particularly suited to adults, who (like adolescents) want their learning to be practical and immediately useful. It has been tested extensively in professional schools. (See Fact Sheet 16: Problem-Based Learning.)

Adult Self-Esteem is Not Helped By Easy Assignments

☞ Because many adults enter programs with low self-esteem, there is a temptation to "boost their confidence" with easy assignments and praise. Unfortunately, this can lead students to think they are stupid, otherwise why would we give them easy assignments? (See Fact Sheet 17: Supporting Good Thinking.)

Interests Are Motivating For Adults

☞ Adult students' reading comprehension over the term improves more when they read about topics they are interested in (such as career interests or health topics) than students who read about "general" topics.[29] (See Fact Sheet 17: Supporting Good Thinking.)

Self-Motivated Learners Can Still Be Oriented To Pleasing The Teacher

☞ Because adults come to school for their own reasons (they are self-motivated), we may mistakenly think that they do not have a "right answer" approach to learning. Yet most teachers have worked with a student who asks after every question, "Teacher, did I get it right?" (See Fact Sheet 17: Supporting Good Thinking.)

Current Motivation Practices Are Probably Less Effective Than They Could Be

☞ In my experience, in adult education:

- We think of motivation as caring about students and using interesting topics.
- We think we a) use learning for understanding and rewards for understanding, b) teach good strategies, and c) reward making real progress more than we actually do.
- We talk about making real-world connections, giving students choices, using group learning, and evaluating student work, but not many programs do.[30]
- We mostly avoid directly teaching effective strategies like summarizing or asking questions because we either think it has to be done in a rote way (and will therefore bore and scare off students) or we think it will not make a difference. (See Fact Sheet 17: Supporting Good Thinking.)

What it means for teachers

See the "What it means for teachers" sections in the individual Fact Sheets.

"Adult Learning Theory" Has Not Been Based On A Wide Sample Of Adults

What is called "adult learning theory" is not based on any wide survey of adult learning. It is a combination of the collective, practical "know-how" of the field and the personal philosophy of several influential adult educators.

The Little Research That Has Been Done On Adults Shows Very Similar Patterns To Children

Very little research has been done on adult learning. However, the studies that have been done show that adults learn in the same way as either normal children or learning disabled children. For example, interest is motivating for both children and adults; of course children have different interests from adults, but they are both motivated by interest.

There are some areas where "common sense" says that learning must be different, such as learning a first language. But learning a first language is clearly a different kind of learning than school learning. And children have a lot of time available to learn, so learning may seem easier to them, even if it uses exactly the same processes as adult learning. We can be fooled by "common sense."

In other words, even though learning may seem different for adults, there is no evidence that it is different. That evidence could perhaps be found some day, but for now we do not have it. And the evidence that we do have points toward learning being the same for adults and children. As Richard Venezky points out, "On one hand, assumptions made for children are often extended without question to adults; on the other, lessons acquired in the investigation of child learning are ignored in the study of adults."[31]

This is not to say that adult education programs should look like "average" K-12 school classrooms. Many of those classrooms do not use what is known about learning. Many of them do not teach for understanding, use drill and worksheets when projects and discussion are needed, and rely on ineffective lectures. But that is not a good reason to ignore what is known about learning, memory, and motivation from large-scale studies. Together with teacher "know-how," these can be a powerful set of tools for being more effective with our adult students.

Lesson Ideas

See the "Lesson Ideas" sections in the individual Fact Sheets.

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Appendices

Appendix A: Annotated Bibliography 195
Appendix B: Are there Learning Styles? 197
Appendix C: What About the Brain? 203
Appendix D: Newsletter Articles 209

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Appendix A: Annotated Bibliography

If You Want To Read More

These are the research-based books and articles that I found most clear and helpful in understanding different topics. Some are surveys of the latest literature, while others are classics that I came back to over and over again.

Books

Adult learning

M. C. Smith & T. Pourchot, (Eds.). *Adult Learning and Development: Perspectives From Educational Psychology*. Mahwah, NJ: Erlbaum, 1998.

The first synthesis of cognitive learning theory, educational psychology, and gerontology. A collection of articles from many perspectives, all informed by cognitive psychology and educational psychology.

Basic science (cognitive psychology)

D. Reisberg. *Cognition: Exploring the Science of the Mind*. New York: W.W. Norton, 1997.

A very readable survey of research on the mind, including thinking, problem solving, and perception.

Applied science (educational psychology)

J.D. Bransford, A.L. Brown, & R. Cocking, (Eds.). *How People Learn: Brain, Mind, Experience, and School*. Washington, DC: National Academy Press, 1999. (Also available in full text at www.nap.edu/openbook/0309065577/html/index.html.)

A very readable synthesis of 30 years of research, commissioned by the U.S. Department of Education. The latest summary of "the new science of learning."

J.P. Byrnes. *Cognitive Development and Learning In Instructional Contexts*. Boston: Allyn and Bacon, 1996.

Reviews what we know about how thinking develops and explains applications in the classroom.

R. Slavin. *Educational Psychology: Theory and Practice* (6th ed.). Boston: Allyn and Bacon, 1999.

An up-to-date, research-based textbook that covers a wide range of topics, including thinking and learning.

D. Halpern. *Thought and Knowledge: An Introduction to Critical Thinking* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum, 1996.

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A very readable research-based survey of the thinking mistakes people make and how to fix them. A textbook for undergraduate thinking skills courses but not appropriate for GED students.

Articles

These are short, but you will probably have to go to a university library to get them.

A.L. Brown, J.D. Bransford, R.A. Ferrara, & J.C. Campione. "Learning, Remembering, and Understanding." In J.H. Flavell & E.M. Markman, (Eds.), *Handbook of Child Psychology, Vol. III: Cognitive Development*, New York: John Wiley & Sons, 1983.
A comprehensive review of learning theory from 1983.

J.S. Brown, A. Collins & P. Duguid. "Situated Cognition and the Culture of Learning." *Educational Researcher*, 18 (1), 1989.
Argues that all learning is linked to the people and place where it happens.

S.R. Goldman, A.J. Petrosino & The Cognition and Technology Group at Vanderbilt. "Design Principles for Instruction in Content Domains: Lessons from Research on Expertise and Learning." In F.T. Durso, R.S. Nickerson, R.W. Schvaneveldt, S.T. Dumais, D.S. Lindsay & M.T.H. Chi, (Eds.). *Handbook of Applied Cognition*. New York: John Wiley & Sons, 1999.
A comprehensive review of learning theory from 1999.

M.G. McKeown & I.L. Beck. "The Assessment and Characterization of Young Learners' Knowledge of a Topic in History." *American Educational Research Journal*, 27, 1990.
Shows how low background knowledge, rote teaching, and poor textbooks interact to produce poor learning.

Journals

These journals are readable, useful, and research-based. I used quite a few articles from each of them in the fact sheets.

Journal of Adolescent and Adult Literacy, International Literacy Association, http://www.reading.org/publications/journals/JAAL/index.html.

Educational Researcher, American Educational Research Association, http://www.aera.net/pubs/er/.

American Educator, American Federation of Teachers, http://www.aft.org/publications/american_educator/.

Phi Delta Kappan, Phi Delta Kappa International [Education fraternity], http://www.pdkintl.org/kappan/kappan.htm.

Appendix B: Are There Learning Styles?

What Does Research Say About Learning Styles?

☞ Many adult educators have taken (or taught) workshops on "learning styles"[1]--the idea that everyone learns best through either seeing (visual), hearing (auditory) or doing (kinesthetic).[2] But there does not seem to be evidence for these "styles" in mainstream cognitive psychology (the study of thinking) or educational psychology. In reading more than 300 mainstream books and articles about thinking and learning, I did not find one that used the learning styles approach. It is widely accepted that learners have unique strengths and weaknesses[3] (I personally think I learn well from songs and not from flashcards; others are just the opposite). But researchers have not been able to find significant:

- Reasons why these three things should be styles **or**
- Reliable tests that can diagnose a style **or**
- Teaching methods that help any style (if there were such a thing) to learn better.

Of course there are probably thousands of teachers and trainers who believe in learning styles.[4] But these personal beliefs conflict with what we know about thinking and learning.

Why Visual, Auditory and Kinesthetic?

The U.S. Army asked the National Academy of Sciences to look into several popular programs that the Army had been told could help people learn or perform better, including learning styles, accelerated learning, learning in your sleep, creative visualization, and others. In 1988 the National Academy of Sciences reviewed the evidence from a 1983 book for visual, auditory, and kinesthetic styles[5] and found that:

1. The "theories" that are supposed to support these styles are metaphors, not mainstream scientific theories. (In fact, the developers do not claim that "learning styles" is a theory.)
2. The "evidence" that is supposed to support these styles is made up of anecdotes, not controlled scientific experiments.
3. The "evidence" does not lead only to the conclusion that there are three styles.
4. The "evidence" was 20 years old at the time and did not refer to many new discoveries since then.[6]

The National Academy of Sciences felt this was very weak evidence and was not strong enough to be acceptable for improving performance, "Overall, there is little or no empirical evidence to date to support"[7] visual, auditory, and kinesthetic styles.

Are the three "styles" separate? The "learning styles" framework says that each person is more strongly either visual (supposedly 60% of the population), auditory (supposedly 37%), or kinesthetic (supposedly 3%). However, there are several studies that contradict these figures. First, several studies show that most people remember better when they learn through several senses, not just one. In other words, a poem will be better remembered if it is set to music and read, heard, and sung rather than just read. The musical tune, rhythm, heard words, and mental image of the page all are clues that can trigger memory for the poem (retrieval cues). Seeing and hearing the song create different memory traces, and more ways to find the memory when it is needed.[8]

Second, there is a very powerful effect of learning by doing that cannot be explained if we accept that only 3% of the population is a kinesthetic learner. For example, in five experiments where people heard words, watched an experimenter do something, or did something themselves, those who "did" remembered from 1/3 to 2 times more than those who just heard, and they remembered for longer.[9] This could be because "doing" usually involves seeing, touching, and hearing as well. Another study compared students who:

1. took a field trip and had to do exercises and take notes, or
2. took a field trip where teachers pointed things out and students checked items on list, or
3. had no field trip.

The actively involved group scored 13% better than the passive group on a test after the field trip and 75% better than the passive group on a test 3 months later.[10]

Third, in 1969, Tom Sticht did a study of 400 U.S. Army recruits. Some low-literate students said they preferred to learn by listening to a tape recording (vs. reading the same material in a book). But they actually learned just as poorly by listening as by reading, which is to say, very poorly.[11] According to Sticht, "Preference for learning in one modality or another does not necessarily mean that learning will be best accomplished under the preferred modality."[12] Interestingly, this same group performed much better when they listened to a tape and followed along in the book than when they had only listened or only read.[13] Another study found that children who scored low on the ability to generate images (low on "visual learning," if such a thing existed) nonetheless remembered more when they used images to learn than when they did not use images.[14] In other words, memory is better when people use two senses rather than just one, even if the student has a preference for one sense.

Overall, "learning styles" is built on a shaky foundation, there is no more evidence for it than there is for learning in your sleep, and certainly less than for direct strategy instruction.

Problems With The "Styles" Tests

Many adult educators have been using "learning styles" tests, surveys, or quizzes to identify students' preferred "style." A good test used to diagnose something should be:

- valid—it can be generalized to related settings,
- reliable—the test comes out the same on people with the same condition, and
- specific—it does not mis-diagnose people.

For example, a college entrance test should be:

- valid—it can be used by everyone who wants to go to college, not just young students;
- reliable—the test comes out pretty much the same from one time to the next; and
- specific—it does not tell you that unprepared students are ready for college or that prepared students are not ready.

A test that is invalid, unreliable, or non-specific should not be used because it will miss too many people who have the condition and mis-diagnose people who do not have it. A 1985 review of Kolb's Learning Styles Inventory found that it was neither reliable nor valid.[15] According to Richard Venezky, a professor at the University of Delaware and a consultant to the U.S. Department of Education, "No reliable instrument for determining learning styles exists."[16]

One problem with the "learning styles" tests is that they ask people how they prefer to learn; they do not test how they actually learn best. Like the recruits in Tom Sticht's study and the students in the visual imagery study, how people think they learn best may not be an accurate picture of how they do learn best. In fact, there is a large body of research on how inaccurate people's judgements are (even college-educated adults) of their own reading comprehension, learning, and memory.[17]

Are There Special Teaching Methods?

Imagine that there was a good test for a student's "style." This would only be useful to teachers if we knew some special teaching methods that worked better for this "style."[18] For example, we do know that students who are focused on just getting the right answer (rather than understanding a problem) perform much worse when a problem is too hard for them.[19] "Optimal challenge" is much more of an issue for these students than for students who are focused on learning for understanding.

So, are there special teaching methods that really would work with certain "styles," if these styles existed? Again, the National Academy of Sciences review found that:

1. A 1984 analysis of 20 studies showed no different effectiveness among teaching methods for students with different "styles." In other words, "visual methods" do not help "visual learners" any more than any other teaching methods, **even though intuitively this might seem likely**.
2. Most studies were done with counselors and clients, and used a survey of how empathetic (not how effective) the counselor was.
3. Some studies were done on bargaining situations, not on conversations held during learning.[20]

Some "learning styles" advocates themselves are not clear on whether to teach **to** students' "styles," or to use other methods to strengthen other "styles."[21] According to the editor of the *International Encyclopedia of Adult Education and Training,*, "Although it is generally assumed that the matching of learning styles with specific instructional methods will enhance both the ability and motivation to learn . . . [there is] little evidence to support this hypothesis." [22]

Overall, educational psychologists have not found that X type of students learn better from Y type of teaching, in learning styles or in other areas.[23] For example, there are not better teaching methods for shy students or students who are oldest children, and so on. Methods that help these students help almost all students. For example, using multiple senses helps all students, visualizable words are easier to remember for all students, learning by doing helps all students.

Bridges to Practice, a research-based 1999 guidebook on teaching adults with learning disabilities, concluded that "There is little research that supports the effectiveness of gearing instruction towards specific learning styles or basing it on the learner's auditory or visual strengths or weaknesses."[24]

Why Do Learning Styles *Feel* Right to Teachers?

There are actually some sound, research-based reasons why asking students about their own learning, teaching a lesson in many ways, and teaching students how to learn (e.g., how to take notes or listen actively) should help them learn, but not because there is such a thing as learning styles.

Asking students about their own learning should raise their awareness of whether they understand or not (see Fact Sheet 4: Thinking About Thinking).[25] For example, when you ask a student who is just pronouncing words off the page, "Explain what you just read," you can influence the student's ideas about what reading is. Students who are more aware of whether they understand what they have read or not tend to have better reading comprehension.

Teaching a lesson in many ways should help students remember what they have learned because there are more ways to retrieve the memory (more retrieval cues). Many teachers using the "learning styles" framework have been doing this for years, because they assumed they had all types of learners. Only those teachers who assumed that all students were "verbal" or that no students were "kinesthetic" have been limiting the number of senses they teach through.

Teaching study skills is also well-supported by educational research, as long as the skills are applied to particular subjects. In other words, general note-taking is not that useful unless the student gets practice and feedback taking history notes, biology notes, and so on (see Fact Sheet 1: Literature is not Science). Many of our students were never taught how to take notes, how to memorize, to ask themselves questions when they read or listen, and so on. Directly teaching them to do these things can really help them learn.

In summary, a lot of the things we have been doing have been working, but not for the reasons we thought they were. Research on metacognitive strategies, encoding, and direct strategy instruction are a better explanation for why this works.

What Does It Mean For Teachers?

Since students do learn differently from each other, what does this mean for teachers? For example, several students have asked me, "What is the best way to memorize?" Now I would probably say, "Here are 10 proven methods. Some of them will almost certainly work for you. The combination that will work for you is probably different from the combination that will work for Mary or Don or me—the important thing is to see which ones work for you."

1. Relate the word or idea to something that you know [See p. 76]. For example, to remember that a caucus is a group of people with similar political interests, relate this to how all the young people get together separate from the adults at a family holiday.
2. Make up a rhyme, jingle, or story to make sense out of the information [See p. 69]. For example, to remember that in presidential elections voters have to **Register**, vote in a Party **Primary**, then a **General** election for **Electors**, remember **R**ich **P**residents **G**et **E**lected.
3. Draw a picture that uses the words or ideas interacting with each other [See p. 78]. For example, to remember that electorate (ELECT + RATE), means voters, draw a picture of people putting ballots in a ballot box (ELECT), with signs that say "51%" (RATE).
4. Explain your word or idea to someone else in a way that they can understand [See pp. 42-43 on summarizing]. For example, explain to your child what a primary election is.

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5. Come up with some reasons for why the word or idea means what it does [See p. 76]. For example, the president is part of the executive branch because a president is like a business executive, he carries things out or executes them.
6. Try to apply your new word or idea in as many areas as you can [See p. 55]. For example, think about every place that elections are held (corporate and non-profit boards, school government, unions, and so on).
7. Imagine questions that a teacher might ask about the word or idea on a test, then try to answer the questions [See p. 39]. For example, what does each branch of the government do?
8. Write down some notes to yourself and get someone to quiz you on them a little bit (5 minutes) every day [See p. 50].
9. Figure out how the information could be useful to you in real life [See p. 17]. For example, you might want a member of Congress to help you with a problem some time, but it would help to have a representative who cared about your issues.
10. Remember that in every study of a proven method, there is a small percentage of students who the method did not work for."

If none of these methods worked with the student, then I would try some other ones (like flash cards), but not until I had tried these well-tested, reliable ones. Perhaps a medical analogy is in order here. If I go to a doctor, I would rather not have the doctor say, "There are 10 pills for your condition—I personally like the pink one." I would feel more reassured to know that one medication was most effective for my condition with people of my age, gender, etc. Since I am a unique individual, that medication might not work well for me, or I could have a rare side effect. Then I might try the next most effective medication. It is even possible that none of these proven medications could work effectively for me without unacceptable side effects. Then I would probably try some untested alternative medicines to see if something worked for me, but not until I had tried out the ones with a proven track record.

We cannot know in advance what combination of learning strategies will help a particular student. But we do have a good set of proven, research-based methods that we can teach to students and help them find what works for them.

NOTES

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[1] At least 20 different "learning styles" or "perceptual styles" have been proposed, including "global vs. local," "field-dependent vs. field-independent," "concrete vs. abstract," "active vs. reflective," and "serialist vs. wholist." See Biggs, J.B. (1996). Approaches to learning. In A.C. Tuijnman (Ed.), *International encyclopedia of adult education and training* (2nd Ed.). Tarrytown, New York: Pergamon.

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[6] Druckman & Swets, *Enhancing human performance*, p.140-142.

[7] Druckman & Swets, *Enhancing human performance*, p. 143.

[8] Smith, L.B. & Katz, D.B. (1996). Activity-dependent processes in perceptual and cognitive development. In R. Gelman & T.K-F. Au (Eds.), *Perceptual and cognitive development*. New York: Academic Press.

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[10] MacKenzie, A.A. & White, R.T. (1982). Fieldwork in geography and long-term memory structures. *American Educational Research Journal, 19* (4), 623-632, p. 630.

[11] Perhaps their expressed preference for learning by listening was really an expressed dislike for reading.

[12] Sticht, T.G. (1969). Learning by listening in relation to aptitude, reading, and rate controlled speech. (Technical Report 69-23). Alexandria, VA: Human Resources Research Organization. Cited in T. Sticht. (1972). Learning by listening. In R. Freedle & J. Carroll (Eds.), *Language comprehension and the acquisition of knowledge*. Washington, DC: V.H. Winston & Sons, p. 288. No inferential statistics were provided—the results may or may not be statistically significant.

[13] Sticht, T.G. (1999, June 9). Listening and reading processes of adults. Presentation at the U.S. Department of Education, Washington, DC.

[14] Scruggs, T.E., Mastropieri, M.A., McLoone, B.B., Levin, J.R., & Morrison, C.R. (1987). Mnemonic facilitation of learning disabled students' memory for expository prose. *Journal of Educational Psychology, 79*, 27-34. Cited in Bruning, R.H., Schraw, G.J., & Ronning, R.R. (1995). *Cognitive psychology and instruction* (2nd Ed.). Englewood Cliffs, NJ: Prentice Hall, p. 85.

[15] Hudak, M. (1985). [Review of] Learning styles inventory. In D. Keyser & R. Sweetland (Eds.), *Test critiques: Vol. 2*. Kansas City, KS: Test Corporation of America.

[16] Venezky, R., Oney, B., Sabatini, J. & Jain, R. (1998). Teaching adults to read and write: A research synthesis. Prepared for Abt Associates, Washington, DC, p. 16.

[17] Metcalfe, J. & Shimamura, A. (Eds.). (1996). *Metacognition: Knowing about knowing*. Cambridge, MA: MIT Press.

[18] Venezky, Oney, Sabatini & Jain, Teaching adults to read and write, p. 16.

[19] That is, students with high performance goals react to high challenge tasks with learned helplessness, while students with high learning goals react to the same tasks with excitement and better cognitive and metacognitive strategy use. Dweck, C.S. & Leggett, B. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95*, 256-73.

[20] Druckman & Swets, *Enhancing human performance*, p.142-143.

[21] Brookfield, S. (1996). Teacher roles and teaching styles. In A.C. Tuijnman (Ed.), *International encyclopedia of adult education and training* (2nd ed.). Tarrytown, New York: Pergamon. Also see N.J. Entwhistle. Study and learning strategies. In *Ibid.*, p. 438-39.

[22] Mackeracher, D. & Tuijnman, A.C. (1996). The implications for educators. In A.C. Tuijnman (Ed.), *International encyclopedia of adult education and training* (2nd Ed.). Tarrytown, New York: Pergamon. See also R.E. Snow. (1996). Individual differences, learning, and instruction. In *Ibid.*, p. 404.

[23] Called an Aptitude-Treatment Interaction or ATI. Venezky, Oney, Sabatini & Jain, Teaching adults to read and write, p. 16.

[24] Bridges to Practice was funded by the National Institute for Literacy. National Adult Literacy and Learning Disabilities Center. (1999). *Bridges to practice: Guidebook 4—The teaching/learning process*. Washington, DC: Academy for Educational Development, p. 6.

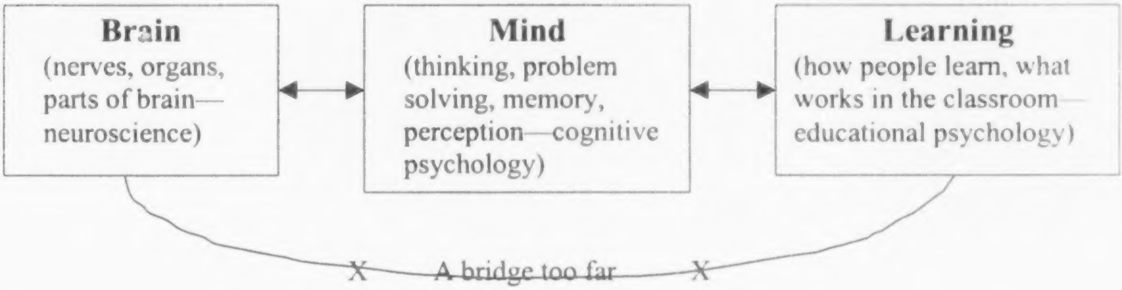
[25] Called metacognitive awareness.

Appendix C: What About The Brain?

The Decade Of The Brain?

☞ Many classroom teachers are enthusiastic about something called "brain-based learning"—usually the idea that information about how the brain works biologically can influence what we do in the classroom. The 1990s was dubbed "the decade of the brain,"[1] and it is true that there have been many recent major discoveries about the biology of the brain, especially ones using CAT scans, MRIs, and other new medical technology. But what does the workings of nerves in the brain--an organ--have to do with how we teach students in the classroom?

Mainstream psychologists have been trying to warn educators that this is, in the words of John Bruer, "a bridge too far"—that brain findings can inform us about thinking,[2] and what we know about thinking can help inform education,[3] but **there is no direct connection between the biology of the brain and how we teach**.[4] All of these connections need to be tested; for example, what we know about memory has to be **tested** in the classroom, because we may not be able to apply what we know directly.


Brain
(nerves, organs, parts of brain—neuroscience)
Mind
(thinking, problem solving, memory, perception—cognitive psychology)
Learning
(how people learn, what works in the classroom—educational psychology)
X
A bridge too far
X

Here is a sample of their warnings:

> "In considering which findings from brain research are relevant to human learning or, by extension, to education, one must be careful to avoid adopting faddish concepts that have not been demonstrated to be of value in classroom practice."—Committee on Developments in the Science of Learning, National Academy of Sciences, 1999.[5]
>
> "You can never go directly from knowledge about brain functioning to what to do in first grade on Monday morning."—Howard Gardner, Harvard University, 1999.[6]
>
> "There is nothing new in this [brain-based] critique of traditional education. It is based on a cognitive and constructivist model of learning that is firmly rooted in more than 30 years of psychological research. Whatever scientific evidence we have for or against the efficacy of such educational approaches can be found in any current textbook on educational psychology. None of the evidence comes from brain research."—John T. Bruer, James S. McDonnell Foundation, 1999.[7]

What Do We Mean By "The Brain"?

☞ In everyday life, we often speak of the mind and the brain interchangeably. "Use your brain." Pooh Bear is "a bear of very little brains." The Scarecrow laments, "If I only had a brain. . ." Difficult puzzles are called "brain teasers" or "Brain Bogglers™." Groups of smart people who work together are called "brain trusts." The process of coming up with new ideas as a group is called "brainstorming."[8] Cognitive psychologists would use the word "mind" to describe these same thinking tasks. So some of the "brain-based" learning arguments are using what we know about thinking--cognitive psychology—to inform education, an idea which has a sound track record. For example, a web site called brains.org posted information about the educational implications of how information is moved from short-term to long-term memory (mind research) as well as the classroom implications of an outdated[9] model of the brain (Paul McLean's "triune brain").

☞ However, some people who talk about "brain-based" learning really are arguing that direct connections can be made between what brain biologists have found out about that organ and how to teach students without using what cognitive psychologists have found out about thinking.

What Are The "Brain-Based" Arguments?

There Is No "Right-brain/Left-brain" Thinking

☞ Probably the most popular "brain-based" learning idea is that of "right-brain/left-brain" learning (and teaching). There are three issues in the "right-brain/left-brain" argument:
1. Are the left and right hemispheres of the brain totally specialized?
2. Do people fall into "thinking types" because they are more "right brain" or "left brain"?
3. Are there proven ways of teaching that reach these "thinking types" better?

The answer to all three questions is NO--there is no "right brain" or "left brain" thinking.

1. Are the left and right hemispheres of the brain totally specialized? While many tasks use one hemisphere of the brain more than another, neuropsychologists have not found school subjects that use only one side of the brain.[10] For example, reading involves the left angular gyrus, both parietal lobes, both temporal lobes, and both occipital lobes of the brain. Contrary to "folk psychology," reading is not just a "left brain" activity[11]—school activities automatically use both sides of the brain. To quote some mainstream psychologists:

   > "Many a myth has grown up around the brain's asymmetry. The left cerebral hemisphere is supposed to be the coldly logical, verbal and dominant half of the brain, while the right developed a reputation as the imaginative side . . . To most neuroscientists, of course, these notions are seen as simplistic at best and nonsense at worst."—John McCrone in *New Scientist*, July, 1999[12]

   > "The practice of teaching to 'different sides of the brain' is not supported by the neuroscientific research."—James Byrnes and Nathan Fox, University of Maryland, 1998[13]

> "Many people have tried to justify their own personal attitude toward almost any issue—art, politics, business management, education, and here even social programs—on this kind of [brain] research."—Robert Ornstein, psychologist, *The Right Mind: Making Sense of the Hemispheres*, 1997[14]

2. Do people fall into "thinking types" because they are more "right brain" or "left brain"? There is no evidence that there are different "thinking types." There is no test that can measure "thinking types."[15] There is no research in mainstream cognitive or educational psychology that supports the idea of "thinking types" generally. It is plausible, but there is no evidence.
3. Are there proven ways of teaching that reach these "thinking types" better? There is no evidence that different teaching methods would reach different "thinking types," if such a thing existed.[16] There is no research in mainstream cognitive or educational psychology that supports special teaching methods. It is plausible, but there is no evidence. **Meanwhile, there are many, many proven effective teaching methods** (such as relating new information to what is known, generating questions, keyword mnemonics, and so on) **that are not being used**.

☞ The "right-brain/left-brain" methods that seem to work in education probably help students overcome the preconceptions that are getting in the way of their learning. For example, *Drawing on the Right Side of the Brain*,[17] a very popular art instruction book, teaches students to look at the spaces between objects, rather than to draw what they think the objects look like. The method works, but not because it uses the right side of the brain, since both right and left hemispheres are used in drawing.[18]

Metaphors And Arguments

☞ Some "brain-based learning" also uses brain metaphors to argue for certain educational methods. For example, Robert Sylwester, in *A Celebration of Neurons*, argues that "Rats placed into a small solitary cage furnished only with a running wheel stayed active by using the wheel, but experienced no increase in cortical thickness: shades of continual drudgery with workbooks and long division problems."[19] Few educators would argue against the idea that school activities should be made more interesting when possible, but it is not clear why knowledge of how the brain functions supports this particular kind of teaching.

☞ Likewise, the "triune brain" is a popular metaphor in "brain-based learning." In the early 1960s, neuroscientist Paul MacLean argued that the human cerebellum (brainstem) was the "reptilian brain," the limbic system was the "old mammalian brain," and the neocortex was the "new mammalian brain"—three "brains within a brain," each with separate functions.[20] Although MacLean's theory has been criticized by mainstream psychologists[21] and is contradicted by much that is known about brain biology,[22] it is a poetic metaphor that has unfortunately been very appealing to educators. Some have argued that when students are under stress they "downshift" to the "reptilian brain." Again, most educators would agree that students do not learn well under stress, but why does evidence about how the brain functions support this? And what teaching techniques could it suggest based on brain biology?

☞ Another popular program suggests specific physical exercises for broad groups of learning problems. "The Double Doodle [is] recommended for those who can't process information. [It is for students with these] problem areas: spelling, listening, reading comprehension and phonics, math, handwriting. Do the Double Doodle with crayons or markers or pencils and paper; start drawing freehand with both hands. Relax head and eye movements."[23] Clearly, if children are not getting enough exercise, then any physical activity should help them work off some excess energy. But there is no theoretical reason or evidence why the "Double Doodle" should specifically help such a wide range of learning problems or why memorization should be helped by the "Gravity Glider" but not by "Balance Buttons."

☞ In short, the "brain-based learning" literature is full of poor logic and conclusions that many educators would agree with but that are not adequately supported by brain evidence.[24] They also often contain a confusing mix of legitimate cognitive psychology findings together with unwarranted leaps from brain research to education.

NOTES

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[1] Bush, G. (1990, July 17). Presidential Proclamation No. 6158.

[2] Phelps, E.A. (1999). Brain versus behavioral studies of cognition. In R.J. Sternberg (Ed.), *The Nature of Cognition*. Cambridge, MA: MIT Press.

[33] See Bransford, J., Brown, A., & Cocking, R.R. (1999). *How people learn: Brain, mind, experience, and school.* Washington, DC: National Academy Press.

[4] James Byrnes and Nathan Fox argue that educational psychologists should make sure that the cognitive theories their work is based on are compatible with and account for current findings in neuroscience. This is quite different from saying that what we know about the brain directly informs what we do in the classroom. Byrnes, J.P., & Fox, N.A. (1998). The educational relevance of research in cognitive neuroscience. *Educational Psychology Review, 10* (3), 297-342.

[5] Bransford, Brown & Cocking, *How people learn*, p. 102.

[6] Gardner, H. (1999). *The disciplined mind: What all students should understand.* NY: Simon & Schuster, p. 61.

[7] Bruer, J.T. (1999). In search of . . . brain-based education. *Phi Delta Kappan, 80* (9), 648-657.

[8] For an argument that the metaphors we use are not trivial or coincidental, see Lakoff, M., & Johnson, P. (1999). The cognitive unconscious. Chapter 2. In M. Lakoff & P. Johnson, *Philosophy in the flesh: The embodied mind and its challenge to western thought.* New York: Basic Books, pp. 9-15.

[9] "The neuroscientist Paul MacLean took the romantic doctrine of the emotions and translated it into a famous but incorrect theory known as the Triune Brain. . . Most parts of the human body came from ancient mammals and before them ancient reptiles, but the parts were heavily modified to fit features of the human lifestyle, such as upright posture. . . . the human cerebral cortex does not ride piggyback on an ancient limbic system, or serve as the terminus of a processing stream beginning there. The systems work in tandem, integrated by many two-way connections." Pinker, S. (1997). *How the mind works.* New York: W.W. Norton, p. 370-71.

[10] The idea of right- and left-brain specialization got a boost from Roger Sperry's Nobel prize-winning research in the 1960s on epileptic patients who had had "split brain" surgery. See McCrone, J. (1999). Right brain left brain. *New Scientist, 162 (2193)*, 26-30.

[11] Byrnes & Fox, The educational relevance.

[12] McCrone, Right brain left brain, p. 27.

[13] Byrnes & Fox, The educational relevance, p. 310.

[14] Ornstein, R. (1997). *The right mind: Making sense of the hemispheres.* New York: Harcourt Brace, p. 91. Ornstein notes that people have been making right-brain/left-brain arguments since the 4th century B.C., when Diocles of Carystus wrote, "There are two brains in the head, one which gives understanding, and another which provides sense perception." [p. 41]

differences were likely due to the poor education and therefore reading abilities of these groups. Ornstein, *The right mind*, p. 89.

[16] This is not to imply that all subjects should be taught in the same way. For example, in reading comprehension, it is usually best to concentrate on the text, but in my personal experience in playing music it is often best to focus on how the body feels, rather than focus on the printed music.

[17] Edwards, B. (1979). *Drawing on the right side of the brain.* LA: Tarcher.

[18] Bruer, In search of . . . , p. 651.

[19] Sylwester, R. (1995). *A celebration of neurons: An educator's guide to the human brain.* Alexandria, VA: Association for Supervision and Curriculum Development, p. 132. Recent research shows that rats who exercise regularly grow two times as many new neurons as rats who do not exercise (Brain jogging. [1999, June]. *Discover*, p. 25), which could be used to argue the opposite from Sylwester. Other researchers have tried to make ill-fated recommendations for the classroom based on rat studies: behaviorist studies on learning in rats supposedly showed that tasks should be broken down into the smallest possible units and then students drilled until they got it right--which seems to me to define Sylwester's "drudgery."

[20] MacLean himself made some large leaps in terms of applications of his theory, "It will perhaps provide a comforting sense of home base for the reptilian brain if parents teach their children the stars and constellations." MacLean's arguments were first laid out in a series of articles published from 1962 to 1969 and summarized in an essay entitled "Man's reptilian and limbic inheritance." MacLean, P.D. (1973). Man's reptilian and limbic inheritance. In P.D. MacLean, *A triune concept of the brain and behavior.* Toronto: University of Toronto Press, p. 20. MacLean also wrote a book for general audiences in 1990 called *The triune brain in evolution.* MacLean, P.D. (1990). *The triune brain in evolution.* New York: Plenum.

[21] Reiner, A. (1990). An explanation of behavior. *Science, 250*, 303-305.

[22] Pinker, *How the mind works*, p. 370-71.

[23] Vuko, E. P. (1997, February 28). The mind gym: Physical exercises to jump-start the brain. *The Washington Post*, D5.

[24] Bruer, In search of . . .

Newsletter Articles

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Learning in and Out of the Classroom

By Jennifer Cromley, Literacy Leader Fellow, National Institute for Literacy

Your students can add money, but not decimals. They love reading stories but hate reading science. Employers complain that high school graduates "can't write," even the ones who wrote good essays in school.

These are all examples of students failing to **transfer**--to take what they learned in one situation and apply it in another. Transfer is actually a very difficult skill, but we do know six keys to teaching students in ways that will help them transfer what they learn in our classes to other classes, to the world outside, to college, and in the workplace.

1) **Teach skills in multiple contexts**. Don't just do proofreading worksheets out of a textbook; have students proofread menus, newspaper articles, their own and each other's writing, and so on. Every time you teach a skill, have students practice it in many different settings.

2) **Teach when to use the skill, not just how to do it**. Students who know how to add fractions, but don't know when to add fractions are in a lot of trouble. If they are like my students, every time they see fractions, they will start adding them—even if the problem calls for division! Whenever you teach a skill, explain when it will be useful. Estimation is great if you are figuring out how many cans of paint to buy but not if you are custom building a cabinet!

3) **Teach through patterns**. Students who learn spelling through patterns, rather than one word at a time, can figure out many more new words. Multiplication by 9s can be taught as 9, 18, 27 . . . , but it can also be taught as a pattern–10-1, 20-2, 30-3 When you teach new information, can you also teach the patterns that it follows?

4) **Teach for understanding**. No teacher ever thinks she would not teach for understanding. But it is surprising how many questions students can answer without really having any understanding of the topic. For example, a class at an inner-city school I worked in was reading a dramatic story about miners caught in a cave-in. Was anyone still alive? Would the air last long enough? The students read fluently and answered all of the comprehension questions correctly. At the end of the hour, a student raised his hand, "What are all these underage people doing underground?" The whole class had been thinking that the story was about minors, not miners. We need to ask comprehension questions that go beyond what happened in the story, especially asking WHY?

5) **Students need to apply their understanding** when solving problems. A student who read a question about a poem and thinks, "Now, what was the answer to this question the last time I saw it?" is not applying her understanding. The one who tries to understand the poem will apply what she knows better, in and out of school.

6) **Students need realistic ideas about what learning is.** Students who think learning is about "just getting the right answer," will have trouble transferring their knowledge. Students are more likely to transfer if they know that learning is about understanding, not just memorizing facts. For example, a student who actively tries to understand what she reads will remember more than one who reads to "say the words right." The one who reads for understanding can apply her background knowledge (for example, knowledge about gravity) in new areas (such as plant roots growing down).

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Using Analogies in Teaching Adults

By Jennifer Cromley, Literacy Leader Fellow, National Institute for Literacy

Romeo and Juliet is like *West Side Story*. Adding fractions is like adding coins. A computer disk drive is like a record player. A table in the newspaper is like the TV schedule. Negative numbers are like below-zero temperature. The Internet is like a spider web.

Analogies can be a very powerful way to teach, but often we feel like they are sailing right over our students' heads. Analogies work because they make direct connections between what students already know and the new information we want them to learn. This connection with background knowledge is known to improve students' long-term memory for new information. Because adults have such a broad range of experiences, we have many more opportunities to use analogies to explain GED material.

What do we know about teaching with analogies that can make best use of their power?

First, make sure that your students know about the thing you are making an analogy from. For example, "'timber' in logging is like 'fore' in golf" is not a good analogy for GED students (unless they happen to play golf). Likewise, before you make an analogy between World War I and World War II, make sure your students are quite familiar with WWI. Be aware of gaps in your students' background knowledge—do they know about tools and hardware or the sport or job you are using as an example?

Second, start with the part of the analogy that your students are familiar with. If you are using the solar system to help students understand atoms, say, "Remember the solar system . . ." rather than beginning with the unfamiliar atom and keeping them hanging.

Third, be specific about the ways in which the situations are alike--just **how** is an electrical circuit like water flowing through a pipe? It may help to make a diagram for students on the board:

	Electricity	⇔	Water
What flows:	Electrons	⇔	Water
Flow called:	Current	⇔	Water flow
Slows flow:	Resistor	⇔	Narrow pipe

Fourth, be clear about the limitations or possible misunderstandings that your analogy can create. For example, if you use a building with floors below ground to explain negative numbers, remember that there is no "zero" floor. Every analogy has limitations--do not give up on using them, but be aware of their limits.

Fifth, be sure to talk about the differences between the two situations. To return to the solar system, the sun is hot and the earth has life on it; but the nucleus of an atom is not hot and electrons do not have life on them.

Using All the Senses to Help Memory

By Jennifer Cromley, Literacy Leader Fellow, National Institute for Literacy

Information gets into the human mind better when it comes in through many senses instead of just one. For example, a word that is heard, seen, spelled, and acted out in charades is easier to remember than a word that is just heard. Because the word enters your memory through many paths, there are more ways to find the word later when you are trying to remember it.

Varied Exercises--Vocabulary classes where students do one type of exercise (like just making up new sentences) are not very effective. But classes where students do a wide variety of exercises (reading words in context and fill-in-the-blank exercises and matching exercises and making up sentences, and so on) are much more effective. Memory aids like making up a cartoon to remember the word or making a connection to a word you already know helps people to remember. These methods use more paths to get the word into memory, so there are more ways to get the information out when it is needed.

Learning by Doing--Many teachers have a feeling that people learn better by doing, but what evidence is there? Five experiments where people heard words, watched an experimenter do something, or did something themselves, showed that "doing" has a powerful effect on learning. Those who "did" remembered from 1/3 to 2 times more than those who just heard, and they remembered for longer. Doing creates an additional path into memory.

Field Trips--Field trips can also increase student learning right after the field trip and later, **if students are actively involved**. One study compared students who:

- took a field trip and had to do exercises and take notes, or
- took a field trip where teachers pointed things out, and students checked items on a list, or
- had no field trip.

The actively involved group scored 13% better than the passive group on a test after the field trip and 75% better than the passive group on a test 3 months later.

Is this the same as "learning styles"? Yes and no. Yes, people do have ways of learning that work better and worse for them. Yes, students learn better when they think about their own learning. But no, that does not mean we should teach only visually to a visual class! In fact, all students should benefit from using as many senses as possible in learning. The National Academy of Sciences looked at whether learning styles were useful in training, and "found negligible evidence in support of the effectiveness of the specific NLP learning methods beyond that which any system would achieve."

So, what can you do as a teacher? Here are a few ideas:

Choose topics that can be taught with a hands-on component. Consider building scale models, measuring objects, paper cut-outs, role plays or skits, simple experiments, making graphs (instead of just reading them), or baking, sewing or building projects (for teaching math).

Ask students to read, write, listen, and speak about every topic, not just read and answer fill-in-the-blank or multiple choice questions.

Use props, do hands-on projects, and take field trips whenever possible. Students should be actively involved in seeing, doing, measuring, taking notes, and so on. Involve students in planning and researching the field trip. Make sure that your props, hands-on projects, and field trips are related to your class material! Too many field trips are just "a day away from the classroom," not related to lessons.

To teach about biology of plants, use fruits, root vegetables, and flowers. Look at the plants, feel them, smell them, taste them. Have students dissect a flower, plant, and vegetable (do not just do a demonstration in front of the room). Sprout seeds and watch them grow. Connect the way the plants look, smell, and taste with their functions (Do bitter plants keep bugs away? Do colorful flowers attract bees?).

Have a field trip before you learn about a topic. Go to a relevant museum, watch a video or movie, visit a factory or other business or a historic site. Students may need a short briefing beforehand, but they are likely to be more interested in the reading after the field trip.

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Short-Term Memory

By Jennifer Cromley, Literacy Leader Fellow, National Institute for Literacy

Imagine a tiny parking lot that only has room for seven cars. A police officer waves the cars in until all of the spaces are full, and then pulls up a barricade. The next several cars that come along are waved away and they drive off, never to return. Eventually a spot opens up, and the officer lets in whatever cars happen to arrive.

In order for information to make it into our students' memories, it has to get through a short-term memory (STM) system that is a lot like this tiny parking lot. Information that is in front of students when their STM is full will never make it in.

Short-term memory can hold about seven numbers, about five words, or about three nonsense syllables. STM is the gatekeeper for learning—information beyond the seven items cannot be processed or learned.

Information lasts only 10 to 30 seconds in short-term memory, unless it is repeated verbally, just like you repeat a phone number to yourself after you look it up and before you dial it. This "self-speech" does not have to be done out loud; in fact, you do not even have to move your lips. Interestingly, deaf people who use sign language do a similar kind of internal "self-signing" to keep information in STM.

New information, and the thinking that has to be done with that information, compete for the seven spaces in STM. In other words, a student can hold more numbers in her STM if she just has to add single digits, than if she has to do calculus with them.

A student with a wide knowledge of the world will take in new information in "chunks," rather than one item at a time. For example, a student who knows a lot about cars can read and hold the carburetor, spark plugs, pistons, manifold, starter, and fuel injector in one "chunk" in STM—as the engine. For me, this information takes up all seven slots, and leaves me no room to think! So short-term memory is a link to students' knowledge base.

It is surprisingly easy for teachers to overload students' short-term memory. For example, when students learn the IE spelling rule for the first time, they run out of room in STM before they are half-way through the rule:

I	before	E	except	after	C	or
1	2	3	4	5	6	7

To avoid overloading STM, teach this rule over several days. First teach the "IE" and "CEI" parts (6 slots) until students have chunked them (now they take up 2 slots). On another day teach the "when sounding like A as in neighbor and weigh" parts (at first 4 chunks, then just 1). Finally, teach some exceptions: "Neither leisurely foreigner seized their weird heights" (at first 7 chunks, then one sentence).

Another example of chunking is learning the number of days in the months. If you tried to learn each month in order (January-31, February-28, March-31, etc.) there would be 12 chunks. And when you first learn it, the familiar rhyme "30 days hath September…" takes up nine chunks. But once you learn it, it only takes up four chunks, freeing up three more for problem solving.

Finally, try writing things down on the board when you want students to remember them, in order to free up short-term memory. It is much easier to remember tomorrow's homework assignment by writing it down than by repeating it to yourself over and over again.

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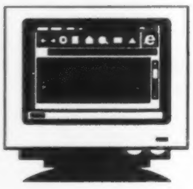
Memory and Learning: Memory Is A Web

By Jennifer Cromley, Literacy Leader Fellow, National Institute for Literacy

If a student cannot remember last week's lesson, it is impossible to learn. Knowing more about memory can help us teach better. Here are some key facts about memory:

- *Information is stored in an organized way in memory.*
- *To learn anything, a student has to associate it to something that he or she already knows.*
- *When students learn something new, they are storing* ***facts****, information about* ***categories*** *(how the new information is linked to other information), and how* ***typical*** *the new information is.*
- *Students understand better when they are reading about familiar topics because information is already activated in their memories.*

So is memory more like a computer or like a filing cabinet? Well, neither one is a good model! If memory is like a computer, students can hear information once, and they should know it. If memory is like a filing cabinet, information is stored in an organized way, and each file is independent of the others.



Computer

- Enter data once and it is in memory
- Data must be entered
- Data can be entered randomly
- Perfect access (information has an address)
- Access depends on address
- Accessible forever
- Each piece of information is separate
- Relationships created automatically

Mind

- Need repetition to get into memory
- Need to do work to get into memory
- Some learning just happens (implicit)
- Information is learned better when it is organized
- Many ways to access, all can fail
- Access depends on practice retrieving
- Memories fade over time
- Networks of information in mental models
- Relationships created by thinking

The idea that human memory is like a computer, with perfect access to information stored in a particular location, is not an accurate one. With this model, simple repetition would guarantee that information gets into the mind and could be recalled instantly. Students who believe this model may call themselves "stupid" when they fail to learn meaningless material instead of realizing that learning needs to fit the way the mind stores information.

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Memory and Learning: What Does it Mean for Teachers?

By Jennifer Cromley, Literacy Leader Fellow,
National Institute for Literacy

Teaching Should Be Based on How The Mind Stores Information

- Relate new information to what students know.
- Help students build concepts (see below).
- Teach new memory strategies like idea maps, learning with many senses, and so on.
- Build associations among information that students already have through discussion and practice.
- Give students lots of practice recalling what they know to build paths out of memory.
- Emphasize how new information is like what students already know and how it is different.
- Activate what students know about a topic before they read (see Fact Sheet 3: Mental Models). For example, ask "We're going to read about banks. What words does that make you think of?"
- Emphasize to students the difference between remembering by repeating (less effective) and remembering by relating (more effective).
- Teach in a way that creates many paths into and out of memory. For example, relating to what you know, using many senses, and so on.

Ask Questions That Build Connections

Claire Weinstein and her colleagues suggest these questions:

"What is the main idea of this story?
If I lived during this period, how would I feel about my life?
If this principle were not true, what would that imply?
What does this remind me of?
How could I use this information in the project I am working on?
How could I represent this in a diagram?
How do I feel about the author's opinion?
How could I put this in my own words?
What might be an example of this?
How could I teach this to my [family member]?
Where else have I heard something like this?
If I were going to interview the author, what would I ask her?
How does this apply to my life?
Have I ever been in a situation where I felt like the main character?"
(From Weinstein, C., Ridley, D.S., Dahl, T., & Weber, E.S. Helping Students Develop Strategies For Effective Learning. *Educational Leadership, 46* (4), 1988/89, p. 17-19.)

Time

It takes time to move information from short-term memory to long-term memory (at least 8 seconds). Students need time to digest information in class.

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Reading Strategies and Reading Development

By Jennifer Cromley, Literacy Leader Fellow,
National Institute for Literacy

How does reading develop? How do people go from hardly being able to make it through a sentence to reading and understanding whole pages, chapters, even books? Although research does not have all of the answers, it offers a lot of useful clues.

First, reading does not seem to develop in a straight line, from letters, to words, to sentences, to paragraphs. All readers, adults and children, are working at many of these levels at the same time. If you have ever read a new book with a 4- to 6-year-old child, you know that they know a few words (like "the"); they are good at guessing words (like "cat" when there is a picture of a cat); and they ask you over and over again, "What is that word?". Each of these methods is a reading strategy, and all readers have many strategies, not just one.

Beginning readers have a few strategies, which they do not use very well. Intermediate readers have many strategies but still do not use them in the most effective way. Experienced readers also have many strategies, but they use them in the most effective way. As readers develop they do not get rid of old strategies, but they change how often they use different strategies.

Beginning readers can recognize a few words, ask for help with many words, and can sometimes sound out words. The strategies they use do not always work (for example, they may mis-pronounce a word when sounding it out). **Intermediate readers** know that in addition they can sound out the beginning of the word and recognize the rest of the word, infer from context, or use a dictionary. But they do not always know when to use which strategy (when to sound out the beginning of the word and infer the meaning from context versus when to use a dictionary). And the strategies they use do not always work (for example, they may not recognize that a friend's definition does not fit the meaning of the sentence). **Experienced readers** use their strategies in the most effective way. That is, they use a few very effective strategies most of the time, but have other strategies available when they need them. For example, you probably recognize most words from sight, but when you come across a new word, you know when to infer the meaning from context, when to look the word up, and so on.

An important role for teachers is to help students both learn more strategies and learn when each strategy is most effective. Surprisingly enough, people do not change the strategies they use because they feel the old strategies are not working. Rather, it seems to happen when people are challenged with difficult problems where familiar strategies are very time-consuming. We often do this when we teach dictionary skills. When students come across a word they cannot sound out, we tell them to look it up in the dictionary. At first, this takes a long time, but with enough practice, the dictionary eventually becomes easier to use, and it becomes a more effective strategy.

At any given time, some strategies are more practiced and more effective than others for the range of problems that one person faces in a particular subject. The practiced strategies are the most familiar and are the ones the person is most comfortable with. Other strategies are not as familiar and the person is less comfortable with them and confident in them. This explains why, for example, students who can sound out words sometimes do not. After all, it is painful to switch from a strategy that you are good at to one that you are not good at and to "go backwards in order to go forwards." So beginning adult readers' strategies may not be the ones we would use, but they work more comfortably for the reader than the other strategies they have.

Perhaps the most important advice to teachers based on this research is to challenge students with difficult problems that require them to use better strategies that they already have but are not comfortable with yet. Create an atmosphere where students "feel successful and competent, but also challenged" (James Byrnes). Recognize that you will need to support students as they struggle with less-practiced strategies and remind them that part of learning is "going back so that you can go forward." Expect students to switch back and forth between using more effective new strategies and more comfortable old strategies.

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Two Dozen Reasons Why Background Knowledge is Important

By Jennifer Cromley, Literacy Leader Fellow,
National Institute for Literacy

Background knowledge improves students' memory

1) Background knowledge helps get information into short-term memory.
2) Background knowledge stored in mental models frees up working memory.
3) Background knowledge helps get information into long-term memory.
4) Background knowledge helps students imagine a situation in their minds, which helps them remember.

Background knowledge helps students understand what they read

5) Background knowledge about word sounds (called phonemes) helps students make sense of what they hear and read.
6) Background vocabulary knowledge helps students make sense of longer sentences.
7) Students with more, better organized background knowledge understand what they read better.
8) Background knowledge helps students understand maps, graphs, and other graphics.
9) Background knowledge helps students read for meaning, which helps get information into memory.
10) Students read faster, understand more, and draw more logical conclusions in familiar subject areas.
11) Background knowledge gives adult literacy students a basis for understanding much more sophisticated reading materials than children at the same grade reading level.

Background knowledge helps students think better and do better at solving problems

12) Background knowledge helps students know what to notice in a problem.
13) Background knowledge is stored in mental models that affect what we see and hear.
14) Students answer questions more logically in areas where they have background knowledge.
15) Background knowledge about types of problems helps students solve problems.
16) However, background knowledge that includes misconceptions can get in the way of learning.
17) Having background knowledge allows students learn from analogies.
18) Background knowledge helps students understand metaphors and figurative language.
19) A lot of background knowledge is specific to different topic areas so students need to get background in many subjects.
20) Students can transfer knowledge better from one subject to another when they have a good understanding of the subject they are transferring from.

Background knowledge affects students' use of strategies

21) Background knowledge helps students learn strategies, because they must have something to use the strategies on.
22) New knowledge forces students to learn new strategies.

Background knowledge helps students know what to notice

23) Experts have more subject knowledge than beginners, which helps them notice patterns.
24) Background knowledge helps students see what is important in a situation and what is trivial.

Problem-Based Learning

By Jennifer Cromley, Literacy Leader Fellow,
National Institute for Literacy

Problem-based learning is a promising new method that could help adult learners enjoy learning more, understand more, and stay motivated.

Problem-based learning (PBL) uses:

- real world problems that
- students are interested in and that
- draw on skills and knowledge from several different subjects,
- have no simple answers, so students have to explain why they chose the solution they did,
- are done by groups of students who work together, and
- include a public presentation to a real audience.

Problem-based learning has been used successfully in K-12 classrooms, college classes, and medicine, business, law, social work, architecture, pharmacy, engineering, and education schools.

Problem-Based Learning always starts from a problem. In other words, students may not know much about the topic before they get the problem, but the problem raises their curiosity and makes them want to know more.

For example, perhaps a chemical treatment plant is being built near your school. You could write a problem that asks students to prepare a presentation supporting or criticizing the plan. They may not already know about chemical safety, drinking water, zoning, public relations, and so on. But if they find the problem compelling, they will be motivated to learn more. You will need to gather the information that students need beforehand and figure out links to GED subjects, such as chemistry, ecology, math, writing, and so on.

The next step is to have a discussion with your students about what kind of information they will need. What kinds of chemicals will be treated? What are the dangers? How many jobs will be created? What is the pay like? What have other communities done in situations like this?

Depending on the skills your class has, you may give them articles or information, or you may have them search the Internet. For beginning searchers, you should provide the Internet addresses (URLs). A more advanced class can use a search engine. The teacher needs to plan carefully so that students have to do some searching and sifting of information, but not so much that they are too frustrated.

Problem-based learning combines several methods that have a solid track record for engaging students and improving learning:

- active student involvement in learning
- group learning
- real-world tasks based on student interests
- hands-on learning
- developing students' self-awareness of their own learning

In a number of different studies PBL has been shown to:

- improve subject-specific problem-solving,
- improve students' planning abilities (e.g., planning an essay),
- improve critical thinking skills,
- improve self-confidence in the subject, and
- lead to as much factual learning as regular classrooms.

For some examples of PBL in adult education classrooms, see the December, 1998 issue of *Focus On Basics* (available on the Web at http://gseweb.harvard.edu/~ncsall/fobv2id.htm.

Glossary

FS stands for Fact Sheet, where the terms are first defined and used.

Note: Because this report is written in non-technical language, only the terms actually used in the fact sheets are defined here. Many other concepts are referred to in the Fact Sheets, but the technical terms are not used there.

Characteristic features	Things that make an object unique (such as a penguin's black-and-white colors or short wings made for swimming, which make it different from other birds). (FS 8)
Chunking	Reducing the load on short-term memory by organizing incoming information. (FS 7)
Cognition	Thinking.
Cognitive psychology	The study of thinking from a psychology perspective.
Cognitive science	The study of thinking from any scientific perspective, including neurobiology, medicine, psychology, and anthropology.
Cue	A hint that helps a person remember something (retrieve information). (FS 5)
Deductive thinking	Drawing conclusions from evidence--If A and B, then C. (FS 14)
Defining features	Things that an object has in common with others like it (such as the fact that a penguin lays eggs and has a beak, which makes it like other birds). (FS 8)
Elaboration	Relating new information to what you know as a way to remember the new information better. (FS 8)
Encoding	Getting information from short-term memory to long-term memory. (FS 5)
Inference	Adding information from your store of knowledge to make sense of something--Read: The man unlocked the door, Add: Keys are used to unlock doors, Infer: The man used a key. (FS 3)
Long-term memory	The memory systems that store ideas or "how to" information permanently. (FS 8)
Mental model	All of the information a person has about a fact or topic. In experts, mental models are detailed and organized. In novices, mental models have little information and are disorganized. (FS 3)

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Metacognition	Thinking about thinking--being aware of whether you have understood what you read, studied enough to be ready for a test, planned out a paper well enough, and so on. (FS 4)
Mnemonics	Memory tricks that actually work--includes visual and keyword mnemonics. (FS 8)
Modeling	Demonstrating good thinking for students by talking out loud as you work through a task or problem. (FS 4)
Primacy	Information that is presented first is remembered better than later information. (FS 6)
Priming	Activating information in the mind before reading. After priming, people recognize words and read more quickly. (FS 8)
Procedural knowledge	Memory for "how to" information which we know automatically, such as lining up digits in an addition problem. (FS 8)
Recall	Being able to pull up information from your memory (like on a fill-in-the blank test). (FS 5)
Recency	Information that is presented last is remembered better than information that is presented earlier. (FS 6)
Recognition	Recognizing information that you have seen before (like on a multiple-choice test). (FS 5)
Retrieval	Getting access to stored information from long-term memory. (FS 5)
Short-term memory	The memory system that information first enters. It is temporary and only lasts about 10-30 seconds unless the person repeats the information to himself or herself. It can store only about 7 items at a time. (FS 7)
Strategy	Any "how to" method such as summarizing, asking a teacher, or the "Min" method in addition that people use to read or solve problems. (FS 4)
Transfer	Being able take what you learn in one subject (graph reading in science) and apply it in another subject (graph reading in economics). (FS 2)

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Index

A

Abstract thinking ... 90, 97
Ackermann, Edith ... 97
Activation ... 76
Active learning ... 77, 147
Active learning, in problem-based learning ... 159
Adult learning, different from children's ... 31, 66, 107, 184, 185
Analogies ... 7, 15, 40, 89
Associations ... 74
Attribution ... 101, 172
Automatic skills ... 79, 126
Autonomy support ... 174
Availability heuristic ... 139

B

Background knowledge ... 4, 27, 29, 32, 38, 66, 68, 74, 102, 108, 117, 138
Background knowledge, and knowing what to notice ... 121
Background knowledge, and memory ... 118
Background knowledge, and problem solving ... 119
Background knowledge, and reading comprehension ... 119
Background knowledge, and strategy use ... 120
Background knowledge, in problem-based learning ... 159
Barnes, Martha ... 145
Belief bias ... 138
Believable arguments ... 139
Biology ... 2, 8, 82, 149
Brain injury ... 61
Brain ... 5, 203
Brown, David ... 93

C

Categories ... 5
Cause and effect ... 2, 89
Challenge tasks ... 100
Characteristic features ... 75
Chemistry ... 2, 7, 103, 174
Chess ... 4
Child development ... 4, 38, 65
Choice in learning ... 174
Chunking ... 66
Cognitive development ... 85, 97
Cognitive development, biological ... 86
Cognitive development, children's thinking skills .. 88
Cognitive development, experience and ... 102
Cognitive development, school-based ... 87
Cognitive development, stages ... 90, 98
Cognitive development, strategy acquisition in ... 100
Cognitive development, strategy use model ... 98
Cognitive psychology ... iv, vii
Computer programming ... 131
Concepts ... 75
Concrete thinking ... 97
Confirmation bias ... 141
Constructivism ... v, 147
Content-based instruction ... 6, 30, 117, 121
Context, in reading comprehension ... 40
Contexts, teaching in multiple ... 13
Cooperative learning ... 164, 175
Counting-all strategy ... 100
Counting-up strategy ... 100
Credibility ... 142, 144
Critical thinking ... v, 11, 137
Critical thinking, definitions of ... 145
Critical thinking, in problem-based learning ... 160
Crystallized intelligence ... 108

D

Deafness, and memory ... 64
Debate ... 104, 145
Defining features ... 75
Demonstration ... *See* Modeling
Depth of coverage ... 103
Detailed information ... 52
Details, noticing ... 48, 141
Development ... *See* Cognitive development
Direct instruction ... 92
Discovery learning ... 40, 151
Discussion ... 104, 178
Domain specificity ... 3
Drawings ... 68-69

E

Economics ... 2, 7
Elaboration ... 53, 76
Engagement ... 171
Evaluation ... 175
Evidence and conclusions ... 143, 144
Examples ... 16
Expectations ... 27, 28, 103
Experience ... 107
Expert-novice research ... 13, 14, 48, 125

F

Familiar topics ... 18, 30, 140
Families and child rearing ... 110
Feedback ... 19, 43, 92, 102, 128

Field trips ... 51
Fluid intelligence ... 108

G

Garvin, David ... 147
GED ... 2, 11, 137, 145, 178
Generation effect ... 149
Geography ... 2
Goal orientation ... 173
Goals, of learners ... 48
Grammar ... 4, 8, 12
Guthrie, John ... 171

H

Halpern, Diane ... 145
Hands-on activitites ... 91
Hands-on learning ... 54, 104, 152
History ... 2, 3, 7, 26, 103, 111, 129

I

Inference ... 29, 147
Interest ... 107, 111
Interest, situational ... 174
Interest, topic ... 173, 190
Interests, student ... 189

J

Jigsaw method ... 179
Jumping to conclusions ... 144

K

Keyword mnemonics ... 78
King, Alison ... 153

L

Language learning ... 5
Learning by doing ... 51
Learning disabilities ... 28, 66, 78
Learning, student ideas about ... 15, 28, 176, 210
Lecture ... 149, 151
Levels of processing ... 49
Literature ... 2, 3
Logic ... 3

M

Main idea ... 145, 149
Math ... 5
Math, grocery store ... 12, 109
Meaningful information ... 50, 79
Memorization ... vi, 78, 158
Memory, getting information into ... 47
Memory, getting information out of ... 50, 78
Memory, improving ... 66
Memory, long-term ... 60, 64, 73
Memory, procedural ... 79
Memory, short-term ... *See* Memory, working
Memory, working ... 60, 63, 108
Mental models ... 25
Metacognition ... 37, 130, 142
Metacognition, in problem-based learning ... 159
Metaphors ... 89, 108
Min strategy ... 100
Mini Page© ... 82
Misconceptions ... 31
Misconceptions, interference with learning ... 101, 109, 128, 133, 187
Mistakes ... 53
Mnemonics (memory aids) ... 68
Modeling ... 31, 42, 102, 152
Motivation ... 171
Multiple choice tests ... 78
Multiplication ... 129

N

National Research Council ... 158

O

Organized information ... 64
Organized knowledge ... 27, 28, 77, 126
Outlines ... 77

P

Patterns ... 14
Patterns, noticing ... 125
Penny ... 50
Performance orientation ... 173
Phonemic awareness ... 112
Physics ... 3, 4
Poe, Edgar Allen ... 107
Practice ... 42, 102
Praise ... 176
Prediction ... 19
Primacy effect ... 61
Priming ... 76
Problem solving ... 3, 27, 29, 159
Problem solving, and short-term memory ... 69
Problem-based learning ... 157
Proofreading ... 141

Q

Questions, importance of asking ... 54, 143
Questions, student-generated ... 39

R

Reading comprehension ... 132
Reading comprehension, teaching strategies for ... 40
Real-life problems ... 7
Real-world learning ... 158
Real-world skills ... 13, 28, 122, 174
Recency effect ... 61
Rehearsal ... 76
Repetition, meaningful ... 50

Research, uses of .... v, vi
Resnick, Lauren .... v, 145
Rewards 175
Rhymes 51, 69
Role play 104
Romeo and Juliet 19

S

Scaffolding, in problem-based learning 164, 165
Self-awareness of thinking 37, 126
Self-esteem 176
Self-speech 65
Semantic networks 73
Siegler, Robert 98
Slavin, Robert 90, 145
Social studies 2, 3
Sound-alike errors 51
Spelling 69
Stories 28, 40
Strategies 109, 185
Strategies, and motivation 175
Strategies, how to teach 42
Strategies, in development 98
Strategies, reading 38
Strategies, subject-specific 2
Strategies, using new strategies in development... 100
Strategies, when to use 28, 126
Summarizing 39, 68

T

Task value 174
Teachers 132
Teaching, by students 151
Tests 175
Tests, type of studying 54
Thinking out loud 41, 44
Thinking skills, general .... v, 1, 4
Thinking, how to teach 102
Transfer 4
Transfer, in problem-based learning 159
Typical objects 75

U

Understanding, learning for 14, 15, 47, 91, 126, 210
Understanding, learning for, and motivation 173

V

Visual memory 151
Visual mnemonics 79
Vocabulary 40, 92, 151

W

Weinstein, Claire 81
Whole language 40
Wigfield, Allan 171
Wisdom 109, 186
Word problems 13
Workplace 109, 186
Worksheets 92
Writing 8, 130
Writing, to free up short-term memory 68

X

X-rays 129, 131

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